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Chemical Energy From Algae 1
Back Cover Picture:
Sunlight Laboratory 5
Cortisone May Treat Hayfever 6
Berkelium (Bk) Joins the Elements 7
Elements in the News 9
The Future of Oil 16
Power Wanted 20
Negative Proton Predicted 23
For the Home Lab:
The Story of Uranium 25
No Common Clay 27
Glass Overcoat For Steel 29
Chemicals May Endanger Foods 34
Rubber Film is Newest in Paint 35
Chemicals Aid Leukemia Patients 36
Plant Growth Hormones 37
Motion Within the Atom 41
The Chemist's Atom 44

Editorial:
Using the Sun
Inside Front Cover

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Using the Sun

➤ To SOME tillers of the soil in the lush parts of the earth the great technologic rush to use the sunshine more efficiently must seem absurd. Let the fields and the forests do the work, inefficient though they may be.

Yet to the future-eyed on this ever-crowding earth who are worried about the fuel and food of the generations to come, there is urgency in the pioneering underway.

Whether or not the great break toward the industrialization of sunshine will come through the attack that is described by Dr. Burk in the leading article of this number of CHEMISTRY, it is certain that increasing use will be made of the sunlight.

In the parts of the country where the climate is not too severe, it is possible to heat houses in the winter and cool them in the summer by means of heat collectors that store the heat — or the cold, as it were — in the physical changes of chemical substances. Water can be used, but chemicals such as forms of sodium sulphate, which are cheap and plentiful, are even better. Experiments by Dr. Maria Telkes of Massachusetts Institute of Technology show that three days' heat supply can be stored in this way in a test house. It is not difficult to imagine what such systems might mean to greenhouse heating in the more moderate climates.

California probably has more to gain from this development than any other part of the nation. For there it would be possible to heat houses and, more important, it might be possible to solve the shortage of water by large installations of solar distillation apparatus to convert seawater into fresh, drinkable water. These would be along the lines of the solar distillers for life rafts during the war. Shallow trays of transparent and black plastic, rolled out over the land, would allow the sunshine to vaporize the water which would condense and trickle down at the rate of about a quart per day for each square foot.

For such places where the rain does not come, this would be the practical equivalent to a heavy rainfall annually, which would be constant and easily collected.

These are alternatives to the more chemical methods of what might be called synthetic photosynthesis. Many methods of using the energy of the sun more efficienctly will probably be developed. These prospects show that our great era of scientific exploration is far from finished.

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—National Institutes of Health photo.

➤ CHLORELLA *need water, carbon dioxide and certain mineral nutrients including fixed nitrogen. Dr. Dean Burk is here watching experimental cultures in which these minute green algae perform photosynthesis. Bubbling carbon dioxide through the columns in which they are suspended keeps the chlorella moving about, to get their share of food and light.*

Chemical Energy From Algae

by DR. DEAN BURK

National Institutes of Health, U. S. Public Health Service. In a radio talk over C.B.S.

➤ UP TO a year ago it was widely believed that photosynthesis, the process whereby green leaves take sunlight energy and change it into food energy, is not very efficient. That is, that only 10 to 20% of the light energy could be changed into chemical energy.

In our studies during the last year we have developed a process whereby some 80% of the sunlight may be used to form food such as sugar, which may then be readily converted into scarcer and more desirable food, such as fat and protein.

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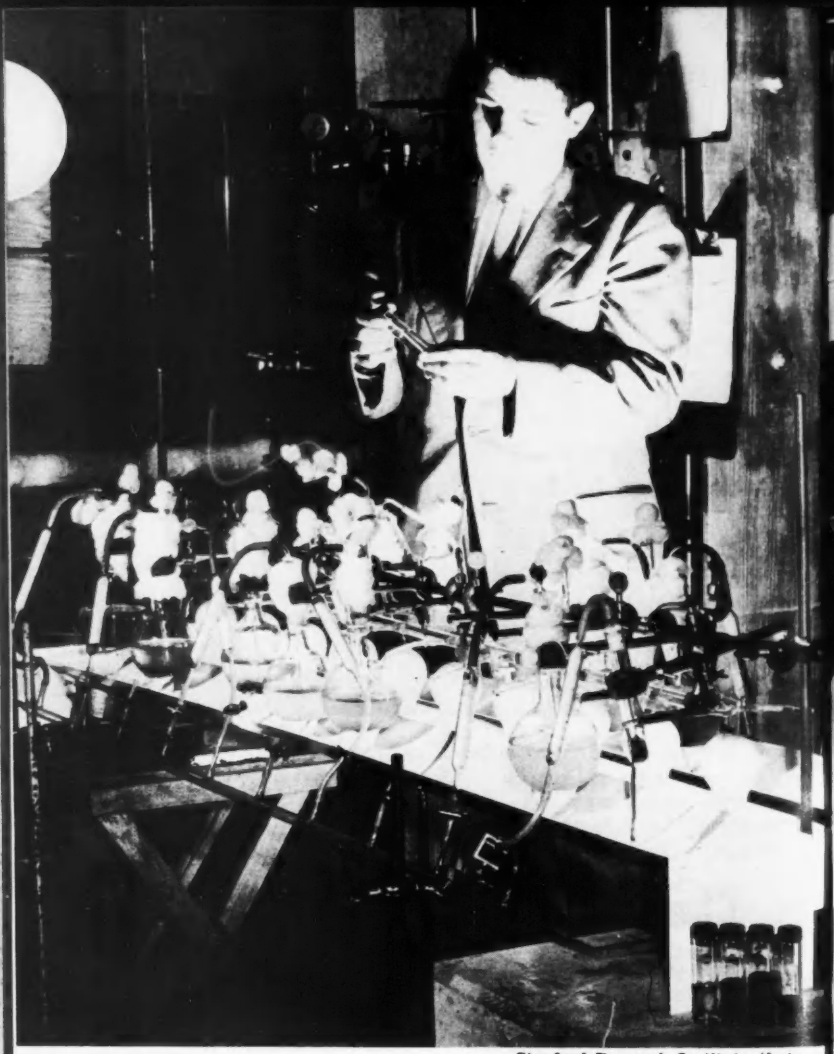

—Stanford Research Institute photo

➤ EFFECTS *of various kinds of solutions on the growth of chlorella are determined on the batch line shown here in operation as the minute organisms absorb a constant amount of light from the electric bulbs beside them.*

—National Institutes of Health photo.

▶ Dr. Burk *and an associate confer about chlorella culture problems with Dr. Otto Warburg (center). The 1931 Nobel prize winner has recently returned to Germany after working with the U.S. Public Health Service group interested in following this new lead on more abundant food production through more efficient use of sunlight.*

We have done this with little green plants called algae, which you often see growing as the green scum in ponds. Or you could see them in your tap water if you had a microscope. Actually every day you are drinking them in small quantities.

They are so small that you have to put about one thousand of them alongside each other to make an inch. They combine carbon dioxide taken from the air and water from the soil to make sugar and starch. At the same time, oxygen gas is broken out of the water and set free to purify the air. Thus, these algae, like other plants, create the food without which man and other animal life would starve, and liberate oxygen, without which they would suffocate. By providing these algae with the best possible conditions, they are then able to

carry out this photosynthesis with virtually perfect efficiency. All the light energy is converted to chemical energy.

Our group has been using new experimental techniques upon algae. Those in the group include Dr. Otto Warburg, the Nobelist who has now returned to Germany, Dr. Sterling Hendricks of the Bureau of Plant Industry of the United States Department of Agriculture at Beltsville, Md., and Dr. Victor Schocken, now at Harvard. We have discovered how many bullets of light—quanta they are called—are needed to break the water molecule. We find that four quanta of light, and, in some cases, three will do this, releasing oxygen and at the same time changing the gaseous carbon dioxide of the air to sugar. Most biochemists have believed that at least 8 to 12 quanta were necessary. Since less light is required, the efficiency will go up accordingly.

Agricultural crops are vastly less efficient and at best convert only about 1% of the sunlight into food energy. Part of this comes about because the leaves of the crop do not cover all of the acreage exposed to sunlight, and because the growing periods of the crops are limited to a few months of the year. Most of the energy absorbed is used to draw water from the soil into the plant where it is then passed out of the leaves into the atmosphere. None of these and many other causes of inefficiency are present when you are dealing with one-celled plants such as the algae.

Most agricultural crops produce one to three tons per acre per year, and this includes the stalks as well as the grain. With alfalfa, about the highest yield five tons per acre may be produced under the best agricultural conditions.

At the Stanford Research Institute in Palo Alto, California, scientists and engineers working together have been able to grow algae at the enormous rate of nearly 50 tons per acre. It is my opinion, based upon our own work already mentioned, that even this harvest could probably be increased four times, making a total yield per acre with algae as the crop some one hundred times as great as with ordinary agricultural crops. Thus a one-acre algae farm could be equivalent to a 100-acre field of wheat or corn.

The present pilot plant experiments at the Stanford Research Institute convert about 5 per cent of the sunlight into energy represented as algal growth. In view of our new results, this could probably be improved about four times, up to at least 20 per cent. The remaining difference between 20 to 100 per cent represents the still fairly large amount of sugar that the algae must use to make themselves out of the sugar they have manufactured, and out of the necessary minerals that must be supplied. The total cost of the raw materials needed to make the algae from air, water, sunlight and mineral salts is less than a cent a pound of algae. Such algae would normally contain 60 per cent protein. It is interesting that under special conditions the algae may be made to consist of 85 per cent lipid or fatty material. If one wanted to produce the same kind of food materials from yeast instead of from algae, it would be necessary to supply several pounds of raw materials such as sugar or molasses to make one pound of

yeast, but with the algae no such extra cost is added since the energy is provided by the sunlight.

Photosynthesis represents a vast potential supply of energy when properly harnessed and utilized. The amount of sunlight falling on the surface of the United States each day is equal to several thousand times the amount of energy used by everybody in one day.

The average person uses some 3,000 calories of food per day, and also 50 times as much more for all fuel needs, including heating, transportation, manufacturing and lighting. This is a total of about 150,000 calories per person per day, whereas the solar energy falling on the United States is about three hundred million calories per day for each person. This amount of sunlight also represents a far greater potential source of energy than is at present considered to be available from nuclear materials in the form of atomic energy.

Virtually all the energy that we do use, coming from coal and oil, was derived originally from photosynthesis carried out in earlier times. The days of easy geographical search for more fuel and power are past, and new methods of using photosynthetic energy, as well as atomic energy, must rely on modern science and engineering.

The future efforts at using photosynthetic energy will include a study of the intimate chemical mechanism of photosynthesis. Much time and research will now be spent trying to find out just how the algae and other plants change carbon dioxide and water into sugar. When this is done, and it will be done, it should be possible to take the process of photosynthesis away from nature and beat her at her own game. The first step in this process will be to break the plant or algal cells apart and try to accomplish photosynthesis in the absence of life.

It has already been possible to carry out half of the total process in the absence of the living cell. That is with the broken up parts of the cell, which are so small that you cannot see them even under the most powerful light microscope, it is now possible to use light to decompose the water into oxygen gas and hydrogen. It now remains to find a way to combine this hydrogen with carbon dioxide to yield sugar. When this has been done, and the process thoroughly studied, it may then be possible to replace entirely the cellular enzymes of the broken up cells with other similar chemical catalysts that can equally well change carbon dioxide and water into sugar

The problem of how to make protein and fat food from sugar is, of course, a separate problem, and will for a long time probably best be solved by the algae in plants. The chief object of the strictly chemical process referred to will be to convert sunlight energy into chemical energy.

On the Back Cover

➤ SUNLIGHT *laboratory obtains information on the rates of growth and production of chlorella under the varying light conditions in nature. The four-inch column appearing at the extreme left in the picture is pivoted so that it may be swung to any desired angle to the sun.*

—Stanford Research Institute photo.

Allergic Research Gets New Direction From Arthritis Remedy

Cortisone May Treat Hayfever

➤ CORTISONE, the new and famous though scarce remedy for rheumatoid arthritis, may point the way to better treatment for hayfever, asthma and other allergies.

This suggestion comes from Dr. Louis Prickman of the Mayo Clinic, Rochester, Minn., where Cortisone's value in rheumatoid arthritis was discovered.

Cortisone is not suggested directly as a remedy for allergies by Dr. Prickman. Its success in relieving arthritis symptoms indicates "a promising new direction for allergic research." Rheumatoid arthritis and allergic diseases have any number of features in common and the underlying mechanism may be the same.

The allergic reaction, whether it comes as hayfever, asthma, hives or a reaction to penicillin, is a defensive process, Dr. Prickman explains. It is a "warning on the part of nature" that the cells of the body have met a harmful substance.

The outer rind, or cortex, of the adrenal glands which produce the hormone now called Cortisone is known to take part in an "alarm reaction" when the body gets under fatigue and psychological stresses. Infections, fatigue and nervous factors appear to be important causes of many of the cases of severe asthma, hives and other allergies which come on after middle age and usually without any specific cause such as a pollen, horse dander, certain foods, and the like.

This picture of allergies is the reason Dr. Prickman thinks allergy fighting might go ahead faster and more successfully by following the Cortisone-ACTH leads.

ACTH is the scientific shortname for another hormone chemical, the adrenocorticotropic hormone. This hormone is produced by the tiny pituitary gland in the head, and acts to stimulate the adrenal gland cortex to produce its hormone. ACTH has been found as effective as Cortisone, the adrenal cortical hormone, in rheumatoid arthritis but supplies of it are just as scarce as supplies of Cortisone. At present Cortisone is being partly synthesized, starting with bile from slaughtered cattle. The synthesis is extremely complex and difficult.

Possible plant sources, from the seeds of a vine, growing of which is illegal in Africa, to the tropical yam of the western hemisphere, are now being intensively investigated.

Raw cabbage juice has bactericidal action, some varieties more than others; Cato, the Roman philosopher, was right when more than 2000 years ago he recommended the use of mashed cabbage for the treatment of bruises.

Newest and Heaviest Element Named For Place of Its Creation

Berkelium (Bk) Joins the Elements

➤ CREATION of a new chemical element, No. 97, heaviest so far found, has been accomplished in the 60-inch and 184-inch University of California cyclotrons. The new element has been christened berkelium, and its symbol is Bk.

It has been predicted for several years. (Chemistry, March 1948, p. 11.) Four years of research led up to the discovery.

The Atomic Energy Commission sponsored the research of the University of California radiation laboratory.

The next lighter elements, americium, No. 95, and curium, No. 96, similarly made in the Berkeley cyclotrons, are very radioactive. None of these is of use in atomic bomb production, the official announcement gave assurance, although element 94, plutonium, is the prime material of the bombs.

The 241 isotope of americium, element No. 95, was irradiated with helium ions to produce the new element, resulting in the production of an isotope of element 97 which is 244 or 243 in weight. The new element is short-lived. It decays by electron capture in a 4.5 hour half-life.

Element 97 was separated by a combination of precipitation and ion exchange adsorption methods, making use of anticipated properties. These include oxidation states and the element's position in the periodic table as a member of the actinide transition series. Its distinctive chemical properties and equally distinctive decay properties constitute the primary evidence for the creation of the new element.

Since the announcement of the production of No. 97 specified "an isotope" or variety of the element, it will probably be found to have several isotopes, one of which has so far been announced. Some of these may have higher weights, probably as high as 247 or 248, based on statements two years ago by Dr. Glenn T. Seaborg, co-discoverer, who led the groups that produced the other new cyclotron-produced elements. Uranium No. 92 is only 238 in its commonest form.

By naming the new element after the city of its birth, Berkeley, the discoverers, Dr. Seaborg, Dr. Stanley G. Thompson and Dr. Albert Ghiorso, have followed the tradition of element naming contained in the periodic table of elements. No. 97 is in a corresponding place in the actinide series of the table to No. 65 in the rare earth, or lanthanide, series. No. 65 is named terbium after the Swedish town, Ytterby, where the mineral was found in which Gadolin, a great investigator of rare earths, discovered the first of these elements. Actually four elements are named after this town: yttrium, erbium and ytterbium, as well as terbium. So it is in line to christen the new chemical baby berkelium, and the symbol will be Bk.

since Be is already used for beryllium, No. 4, a light metal at the other end of the chemical scale.

There is every confidence that No. 98 will also be discovered or may even have already been discovered. The building of such heavy elements of fleeting life is one of the achievements of the giant accelerators that can smack atomic particles into matter, making them stick together and thus transmute into elements never before made. Even heavier elements may be made in the future, when more powerful accelerators are used on the process.

Nine chemical elements, five of them beyond uranium 92 and manufactured in the Berkeley cyclotrons, have been discovered in the past dozen years. Besides 93, 94, 95, 96 and now 97, elements 43, 61, 85 and 87 have been discovered, largely as a by-product of the atomic bomb research. The periodic table is now complete through No. 97.

You can now write in Bk and Berkelium in the blank space for 97 on your copy of the Periodic Table of the Elements, originally published as part 2 of CHEMISTRY *in December 1947, frequently reprinted, and only recently brought up to date by addition of symbol changes adopted by international agreement.*

Uranium in Norwegian Fjord Mud

➤ URANIUM-CONTAINING black mud can be dredged up from the bottoms of some of the fjords that cut deeply into the coast of Norway, states Dr. Kaare M. Strom of the University of Oslo in a communication to the editor of the British scientific journal, *Nature*.

The atomic-energy element, however, is not present in high enough concentration to justify scooping out the mud and working it as an ore. It is of interest primarily as a possible means of determining under what geologic conditions the uranium-containing black shales now found in the Norway hills may have been formed, perhaps half a billion years ago.

Uranium concentrations in present-day fjord-bottom muds range from 13 to 60 grams per metric ton, Dr. Strom's analyses show. This is roughly equivalent to a range of from one-half ounce to two ounces per English long ton of 2,240 pounds. This is far below present levels for workable uranium ores; the U. S. Atomic Energy Commission will purchase such ores only when they contain more than two pounds of uranium oxide per ton.

As having possible bearing on the question of the origin of uranium-containing shales, Dr. Strom points out that the highest concentrations are in the blackest of the fjord-bottom muds, which come from situations where little oxygen penetrates and where only bacteria of the anerobic, or "airless" type can thrive. Well-ventilated muds, inhabited by air-using bacteria, are lighter in color and lower in uranium content.

Wild blueberries, if eaten raw, contribute vitamin C to the body in a quantity only slightly less than canned tomato juice.

Air Is Mined for Gold and Silver, Other Elements Make the Headlines

Elements in the News

➤ THE AIR is being mined for a million dollars and more worth of gold, silver and other metals.

A Los Angeles chemist, Walter A. Schmidt, told how it's done at the United Nations Scientific Conference on the Conservation and Utilization of Resources.

Valuable quantities of minerals, precious and otherwise, are released into the air as industrial wastes, Mr. Schmidt explained. Smoke from improvident factories may be worth a fortune.

Industrial plants which have taken measures to recover these minerals have been well repaid.

Here are some of the findings reported by the chemist:

"One smelter recovers more than $1,000,000 a year in gold, silver and copper out of the gases from 12 multiple-hearth roasters.

"One mint recovers more than $100 a year in gold and silver from the gases ventilating its refining furnaces.

"One lead smelter recovers more than $300 a year in lead and silver out of the gases from 10 sintering machines."

Cobalt Vital to Life

➤ COBALT is one of the most essential elements in the very fundamentals of life processes and the cobalt-containing anti-pernicious anemia vitamin B12 is the most powerful factor in the health of living things ranging from man to the green scum on ponds.

This was indicated by Dr. S. H. Hutner, of the Haskins Laboratories, New York, to the American Philosophical Society.

In experiments with one-celled algae he has show that cobalt enters into the molecules of the B12 vitamin, which in turn is concerned with the manufacture of desoxyribosenucleic acid that is used by the bearers of heredity, the minute genes, which provide the life chain in reproduction.

We know much less about the metals requisite for life in trace amounts than we know about the organic constituents of living things, Dr. Hutner said. Iron, manganese, zinc and copper, in addition to cobalt, are known to be necessary to both animals and plants, while molybdenum, boron and possibly other metals are needed by plants and possibly by animals.

The green alga known as *Euglena gracilis* corresponds to human beings in its need for various elements, Dr. Hutner said, and it can be used as a test animal for assaying the amount of vitamin B12 and the effectiveness of liver extract.

Strontium Isotope Useful

➤ A RADIOACTIVE chemical from the atomic pile is now being used instead of radium or the related radon for treatment of certain eye conditions, three Cleveland, Ohio, scientists announced at a recent meeting of the

American Roentgen Ray Society. The scientists are Dr. Hymer L. Friedell, Dr. Charles I. Thomas and Jack S. Krohmer.

The chemical, radioactive strontium, is put into a lucite capsule which completely encloses it and this capsule is then deposited in an aluminum applicator. This is used in direct contact in treatment of such eye ailments as superficial tumors, or growths, corneal ulcers and the inflammatory condition, conjunctivitis.

It is the beta rays from the radioactive strontium that are effective in treating these conditions, the Cleveland group explained. Their short range is particularly useful because deeper tissues such as the eye lens are not reached and therefore not damaged.

Radium and radon emit beta rays but they also emit the more deeply penetrating gamma rays which must constantly be guarded against in treatment of eye conditions. The lack of gamma rays constitutes one advantage of the radioactive strontium.

Blood Polices Tantalum

➤ TANTALUM, the non-irritating metal now much used for skull plates, permanent bone braces and other surgical purposes, is nevertheless treated as an alien substance by those vigilant policemen of the blood, the white corpuscles.

What happens when tantalum comes into intimate contact with living body tissue is graphically shown in a motion picture film recently made by Dr. Carl C. Speidel, University of Virginia anatomist. Funds for the motion picture were granted by the American Cancer Society.

In making the film, Dr. Speidel used a technique which he has developed over a period of more than 15 years. An anesthetized tadpole is placed on the stage of a high-power microscope, and events in living tissue are studied and photographed in slow motion through its practically transparent tail.

Tantalum, in the form of sheets, fine wire and powder, was introduced into various tissues of the tadpole tail. Always its reception was the same. The white corpuscles hurried to the scene, and like human policemen forming a cordon in front of a crowd, they blocked off the metal from the rest of the tissues with a solid wall formed of their own bodies. Small isolated particles of tantalum powder are picked up and carried off through the circulation, but larger masses of the powder are walled off as if they were solid.

Beryllium Damage to Skin

➤ BERYLLIUM causes the same kind of damage to the skin when its gets into it as it does to the lungs when it is inhaled. The damage in both cases consists of a kind of tumor which doctors call granuloma.

Two cases showing this have been reported by Drs. A. D. Nichol and Rafael Dominguez of the St. Luke's Hospital in Cleveland in the *Journal of the American Medical Association*.

The physicians suggest that this skin condition can be prevented by cutting out the area contaminated by the beryllium before the cuts are allowed to heal.

Both patients had accidentally been cut by broken pieces of fluorescent light bulbs which are coated with

zinc beryllium silicate. The cuts healed quickly but subsequently tumors made up of small fleshy masses formed in the scar. There was also ulceration and inflammation at the site of the cut.

Sections of this skin, removed for study, showed that beryllium was present, according to the doctors.

The patients had also developed lung poisoning from working in beryllium-contaminated air to which one had been exposed for four and one-half years and the other for six years. Drs. Nichol and Dominguez noted no change in the lung infection following removal of the beryllium deposits in the skin. Previous reports indicate, they said, that the lungs are not affected by beryllium infection of the skin. The lung damage comes from inhaling the metallic element.

Iodine From Oil Wells

➤ NEARLY HALF the 1,500,000 pounds of iodine used annually in America now comes from oil wells, according to *Industrial and Engineering Chemistry*, a publication of the American Chemical Society. The iodine is obtained from a brine that comes up with the oil.

Obtaining iodine from oil-well brine is not new. Its first recovery from this source was in 1926 in Louisiana. Oil wells on the West Coast, however, are now supplying the widely used chemical in large amounts, decreasing greatly the amount that must be imported.

The chief use of iodine is as a germicide. It is a familiar medical for cuts and bruises in many households. It is also used as a vital element in cattle feed, in photographic films and in dyes. It is used in methyl iodide, one of the newer gases employed in fire extinguishers, and in a number of other important iodine compounds.

Much of the iodine used in the United States comes from Chile, where it is found as an impurity in saltpeter. Some comes from Japan where it is obtained from the ashes of seaweed. There is considerable iodine in ordinary seawater, but not enough to make its recovery economical.

In the process of recovering iodine from oil-well brine, the chemical is literally blown out of the oil brines in huge towers built with acid-proof bricks, this article states. It is then captured from the air and solidified. The report, prepared by Frederick G. Sawyer, of the *Industrial and Engineering Chemistry* staff, in collaboration with M. F. Ohman and Fred E. Lusk of the Dow Chemical Company, asserts that sufficient quantities of oil-field brine are available in this country so that in an emergency the entire iodine requirement could be obtained from domestic sources.

Zirconium Makes New Light

➤ A POOL of molten zirconium at a temperature of near 6,500 degrees Fahrenheit provides the light in a new lamp which has a brilliancy one-eighth that of the sun. This was revealed at a meeting of the Society of Motion Picture Engineers by W. D. Buckingham of the Western Union Telegraph Company.

The particular applications for which this new light is suitable are in the fields of projection, television, photography, lithography and photocopying. It will also have wide medical and scientific uses, and will be of

especial importance in color photography.

It was described as a high-power, high-intensity electric arc light whose luminescent source is two-tenths of an inch in diameter. It operates in the open air and not in a glass bulb. It is said to be extremely stable in operation, producing a uniformly bright, sharply defined circular spot of white light of dazzling brightness. In a 1000-watt lamp, operating at 55 volts and 18 amperes alternating current, the light has 20 times the brightness of the ordinary tungsten filament lamp.

In spite of operating in the open air and at this extremely high temperature, the lamp can be made to have a life of several hundred hours, Mr. Buckingham explained. This is due to a unique operating principle whereby the zirconium metal is constantly renewed and reproduced from its own products of combustion. The electrodes are small and can be easily replaced. The new lamps may operate on either alternating or direct current.

Aluminum-Welding Process

➤ A GREATLY IMPROVED process for welding aluminum was revealed recently by Battelle Memorial Institute. It utilizes a new pistol-shaped welding tool, through which filler metal in wire form is fed at controllable rates of speed, while the welding electric current is carried through the filler wire, forming an arc between its end and the work.

A sheath of argon or helium gas surrounds the arc and prevents air from coming into contact with the molten metal. Power may be supplied from a standard welding generator. The equipment includes both semi-automatic gun and full automatic equipment.

The process and equipment are the result of joint research conducted at this well-known industrial research center at Columbus, Ohio, and in laboratories of the Air Reduction Sales Company at Murray Hill, N.J. This company manufacturers oxygen, acetylene, inert gases and various types of welding equipment.

Aluminum plates one-eighth to three inches or more in thickness can be welded with the new process, which is to be known as "Aircomatic." The operation is claimed to be at least four times faster than any previously known process of welding aluminum which produces welds of equal quality. It requires less skill. No solid fluxes are required. There are no slags to be cleaned from welded joints, and the welder's work is not interrupted to change electrodes. Welds can be made in any position, flat, horizontal, vertical, or overhead.

Bright Finish For Metals

➤ BY MERELY DIPPING in a chemical solution some metal products are given a bright, reflective finish without mechanical polishing by a new process developed by Battelle Memorial Institute. The method will be known as chemical polishing.

Its chief advantage in production is its simplicity. Items of intricate form can be quickly polished to a high mirror-like luster by this dip treatment. The surface obtained may serve as the final finish surface or as a base for subsequent plating. A 5[illegible]% reduction in finishing costs over or-

dinary mechanical or electrical polishing may be possible with the new process.

It works best on nickel silver, copper alloys, especially 70-30 brass, Monel metal, nickel or aluminum. It can not be used on steel, stainless steel or die cast metals.

The baths into which the metal parts are dipped for chemical polishing contain a mixture of acids, the chief ones being phosphoric, nitric and acetic acids. They operate at ordinary room temperatures and up to 200 degrees Fahrenheit. At the lower temperature, action in the bath is slower and longer immersion time is required. Immersion periods vary from 10 seconds to 10 minutes, depending on the initial finish of the surface being treated, the final finish required, and the operating temperature of the bath.

Following the dipping, the work is rinsed and dried. If it is desired to plate over the chemically finished surface, this can be done without further treatment of the surface.

The chemical polishing process has already been well tested on many metal products. Those successfully polished include brass, copper, nickel-silver, Monel, nickel and aluminum. The action in each case is a true polishing action and the reflective surface obtained is in the polished base metal, not in a deposited coating of a different metal.

Selenium Aids Research

▶ SELENIUM, the "Mr. In-Between" of the chemical world, can be a valuable research tool in fundamental chemistry studies, according to Dr. James D. McCullough, associate professor of chemistry at the University of California at Los Angeles.

This element—rarer than uranium—is situated half way between the metals and the non-metals and displays the characteristics of both.

Although produced at the present time as a by-product of copper and sulfuric acid, selenium has little practical use except when used in small amounts in the making of photo-electric cells and rectifiers in AC-DC radio sets.

Dr. McCullough is excited about selenium because he thinks that an intensive study of its compounds may reveal information valuable to a fundamental understanding of general chemical structures.

Selenium's intermediate position in the family of elements gives it a distinct advantage in X-ray crystal structure studies. Lighter elements are more difficult to locate in molecular studies, while the heavier ones absorb the X-rays too strongly.

Elementary selenium exists in three forms, Dr. McCullough points out. Two forms of it, with a ring-like structure of eight atoms to a molecule, are red crystalline substances and in certain respects resemble sulfur. The other is in the form of a metal-like substance, the crystals of which are made up of chains of selenium atoms.

American Manganese Ores

▶ IMPROVED PROCESSES for obtaining manganese for steel-making from domestic low-grade ores give promise of freeing America from dependence upon foreign supplies, particularly from Russia.

Importations from all sources now total over 1,500,000 tons a year, and

the domestic production is very small. Modern steels can not be made by known methods, except at greatly increased cost, without manganese. In prewar days, the principal source of manganese for American steel-makers was Russia. Now large quantities are obtained from India and Africa.

A process for recovering manganese from low-grade ores by leaching with waste pickle liquor, which is produced in large volume in certain steel manufacturing operations, was revealed recently by Richard D. Hoak, Mellon Institute, and James Coull of the University of Pittsburgh. A high-grade manganese concentrate can be recovered from the leach liquor.

The ore is ground to a fine size, then treated with the waste pickle liquor as the mixture is agitated. Some 95% of the manganese is extracted in a 15-minute period. After filtration, the filtrate is treated with calcium chloride. Calcium sulfate is filtered off. The filtrate from this operation is treated with pulverized high-calcium limestone to separate the iron in it. After the hydrated oxide is filtered off, the filtrate is treated with high-calcium lime to precipitate the manganese. The result is hydrated manganese oxide.

The oxide ores of manganese are by far the most important commercially, Messrs. Hoak and Coull stated. The materials now used in steel-making are largely ferromanganese, spiegeleisen and silicomanganese. The action in steel-making is both as a deoxidant and as an alloying element. As an alloying element, manganese imparts desirable physical properties to a wide range of commercial steels.

A great deal of research has been devoted to the development of processes for utilizing low-grade manganese ores. America has an abundant supply. Dependence on imported high-grade ore from distant parts of the world in times of great emergencies is highly hazardous. Manganese is rated in the United States as a strategic metal. Manganese ore-dressing methods constitute a major project of the U.S. Bureau of Mines.

Placer Tin in Alaska

➤ THERE IS TIN in Alaska, probably not much, but enough to warrant a government survey by the Bureau of Mines. No lode tin of commercial grade was found in the district investigated, but an appreciable amount of placer tin still remains in the Potato mountain tin placer district, the report states.

This district is near the tip of Seward peninsula and is just across the Bering strait from Siberia. It produced some 1,500 tons of tin concentrates in the first two decades of the present century, but none since. It is one of the few places on the North American continent where tin has ever been mined commercially. The United States is dependent on foreign countries for this vastly important and widely used strategic and industrial metal, supplies coming principally from Bolivia and the Far East.

Three New, Stable Isotopes

➤ THREE NEW, stable varieties of chemical elements have been predicted by Dr. Henry E. Duckworth, Wesleyan University chemist, of Middletown, Conn., and one of them, a very rare sort of platinum, has already been detected.

Radioactive isotopes, which are unstable varieties of elements, have been discovered by the dozen in recent years as a result of atom-smashing and atomic energy research. But discovery of permanent elements is rather unusual.

The rare, stable isotopes deduced from the relationships between those known to exist are: tellurium 118, gadolinum 150 and platinum 190. These supposed new ones are all lighter than the most plentiful stable isotopes of these elements.

Platinum 190 was actually discovered by Dr. Duckworth, working with Robert F. Black and Richard F. Woodcock, as a line in a mass spectrum photograph made with a spark between platinum electrodes. The new isotope is one part in about 16,000 parts of commercial platinum.

"MY LITTLE BOY *has been amusing himself trying to make a rocket with his new chemistry set!*"

Petroleum Drought in 15 Years, Industry Prepares Substitutes

The Future of Oil

➤ AMERICAN oil reserves will run out in 15 years and against that day the petroleum industry is spending large sums to develop synthetic fuels.

However, the switchover to synthetic gasoline is not imminent because when natural petroleum is exhausted shale oil and coal should supply our needs for upwards of a thousand years. These oil industry prospects were described by C. K. Viland of the Tide Water Associated Oil Company, Martinez, Calif., on the occasion of the seventy-fifth anniversary of the Colorado School of Mines.

Of the $100,000,000 that is spent each year on petroleum research, Mr. Viland said that "a fair share. . . . .is presently spent on experimental work with synthetic fuels. The industry intends to take the leadership in developing methods for making fuels and lubricants from sources other than crude oil in the future."

Although the American oil reserve is only equal to about 15 years' current usage, Mr. Viland pointed out that Colorado oil shales can produce at least another 100 years' liquid fuels supply. Fuel can also be extracted from coal, and U.S. coal deposits contain enough energy for perhaps 1,000 years at the present rate of consumption.

More Science Needed

➤ PHYSICS, chemistry and other sciences must play very definite roles in research to explore every possible avenue of approach for the physical removal of the greatest amount of oil from proven fields, the American Institute of Chemical Engineers was told earlier by L. E. Elkins of the Stanolind Oil and Gas Company, Tulsa.

In the past 20 years a substantial technical field has been developed in respect to the entire petroleum production industry, added Dr. H. H. Kaveler of the Phillips Petroleum Company, Bartlesville, Okla. The petroleum industry in the first 50 years of its history grew to maturity, he said, with little, if any, help from applied science.

In recent years, when the necessity of conserving the national petroleum resources is a matter of importance, more attention is being given to improvements derived from research and engineering practices. Formerly tradition played the leading role in fixing procedures to be followed in the drilling and development of oil and gas fields. Among present practices, based on chemical engineering, he included drilling muds, reservoir engineering, corrosion control, oil well cementing, acidization of formations, oil well explosives and artificial lift.

With ordinary pumping, considerably less than half the oil in an underground deposit is obtained, it is estimated. By pressure methods, in which natural gas, air or water is forced down to the oil sands, additional crude is obtained. Adding certain

acids and loosening up the sands with explosives are now relatively common practices in obtaining more oil. There is still much left in the sands, however, and new chemical and physical methods are needed, including thermodynamic and hydraulic approaches.

It is demonstrated that research has yet much to do before determining the effect of surface and interfacial tension characteristics on oil, gas and water movement in pores of capillary size, according to Mr. Elkins. Too little is known in the field of capillary performance. Yet the nation's reserves may be increased perhaps five to ten billion barrels if these factors can be truly measured and steps taken either to employ such forces in the recovery of oil, where they are favorable, or overcome their retentive tendencies where such is the case.

Deep Wells Search for Oil

➤ NEW DEVELOPMENTS in drilling 20,000-foot wells in the search for oil were discussed at the Lake Success, N.Y., meeting of the United Nations Scientific Conference on the Conservation and Utilization of Resources (UNSCCUR), by I. S. Salnikov of the Standard Oil Company.

A 1,500-foot well was regarded as deep a half century or so ago, and drilling to that depth was a relatively easy job. America's first oil well, bored at Titusville, Pa., soon after the discovery of oil in 1859, was 69.5 feet in depth. Only 20 years ago, a 9,000-foot well was considered an epic achievement. The first 15,000-foot well was drilled in 1938. Since World War II, four wells in succession have set new records below that depth, and a well in Wyoming, not yet completed, is now below the 20,000-foot mark.

The first oil-well-drilling equipment was the cable tool rig which, in one form or another, has been used to punch holes in the ground since the beginning of recorded history. The standard cable tool method was used in the United States almost exclusively until 1900. A year later the rotary drilling method came into general use in this country. But although steady improvements were made, pre-war equipment is not satisfactory to obtain the great depths of these post-war deep wells.

The most important developments in rotary drilling, Mr. Salnikov told the scientists, are in the unitization and portability of drilling rigs and equipment; better quality steel for drilling equipment; improved designs; improvement in drilling muds; better understanding of hydraulics in mud systems; and proper application of weight on the bit and rotating speeds. Unitization and portability have made drilling more economical but have not added much to the depth problem.

War-developed steels of great strength are now in use in well drilling. Light-weight, high-speed diesel units provide power. Hydraulic drives, in the form of hydraulic couplings and torque converters; radially operated air clutches for use in frequently engaged and disengaged rig drives; air controls of engine throttles, and other services have also been developed by the oil industry in recent years.

Yield From Old Wells

➤ SALVAGING old oil wells may triple total yields in some cases, a petroleum

expert declares. One of his colleagues estimates that oil from this secondary source might amount to 14,000,000,000 barrels.

By flooding old wells with water under pressure, R. C. Earlougher, Tulsa petroleum consultant, believes that yields may range all the way from 25 per cent to 300 per cent of the primary recovery.

These are the extremes and "additional data are needed before a fair estimate can be made," he explained to a petroleum production conference recently.

The 14,000,000,000 barrel estimate of oil from such secondary techniques was made by Paul D. Torrey, president of Lynes, Inc. of Houston. Current estimates of U.S.A. secondary oil reserves are 7,000,000,000 barrels or more, he said, adding that he is "willing to venture the guess that the physically recoverable secondary oil reserve of the nation may be as much as twice this figure."

Although this represents a relatively small proportion of the total reserve, secondary operations nevertheless are an important factor in the business of oil production in several states he said.

Other salvage methods in addition to water flooding, are vacuum pressure, air and gas injection, and, to a limited extent, open mining. Application of all of them, Mr. Torrey said, constitutes a true conservation measure not only in the older oil fields, but in the new fields as well because it prevents the waste of leaving hard-to-reach oil in the ground.

Foreign countries also have such secondary reserves, but so far he said, "no systematic effort has been made to evaluate them."

Synthetic Fuel Plant Sites

➤ MANY AREAS in the United States are suitable for plants for the manufacture of synthetic liquid fuel from coal, oil shale or natural gas as a raw material, recent surveys under government sponsorship show.

Desirable areas, in addition to the necessary raw material, must have plenty of water for plants of large capacity. If coal is the raw material, it should not be types of good coking quality because these are more valuable for other purposes.

Sample surveys already made cover portions of four states. These areas are in western Kentucky, where strip and underground coal are available; northeastern Colorado, with both oil shale and coal; southeastern Texas, with natural gas; and southeastern Montana with strip coal. No efforts were made in these surveys to select specific sites for plant construction. The objective was to determine general areas where all plant requirements can be met.

The surveys were made by the Army Corps of Engineers and by a commercial firm. This group, Ford, Bacon and Davis, Inc., of New York, has been awarded a contract for a nation-wide survey. Summary reports of the four surveys have been compiled by the Corps of Engineers and issued by the U.S. Bureau of Mines.

For detailed study and comparison, general areas within each of the four sample survey states were examined critically with reference to eight major factors, according to Dr. James Boyd, director of the Bureau of Mines. These include raw materials, water

supply, power supply, access transportation, labor and housing, marketing, waste disposal facilities and strategic considerations.

Synthetic Fuel Bibliography

➤ INVESTIGATIONS of the U.S. Bureau of Mines on the production of liquid fuels from oil shale, coal, lignite and natural gas are lisited in a new bibliography issued by that office.

It contains more than 725 individual references to Bureau investigations. In addition to publications issued by the Bureau in printed or mimeographed form, it includes references to articles written by Bureau staff scientists, engineers and technologists for the technical press and to cooperative reports on work done jointly with States, colleges and industries.

A free copy of the report may be obtained from the distribution section of the Bureau of Mines, Pittsburgh 13, Pa. It is Information Circular 7534. Its full title is "Revised Bibliography of Bureau of Mines Investigations on the Production of Liquid Fuels from Oil Shale, Coal, Lignite and Natural Gas."

Improvement in Synthetic Tanning

➤ IMPROVEMENT in leather tanning with synthetic chemicals in what is known as the dialdehyde-resin process, first announced a year ago, is reported by A. H. Winheim, of the Planetary Chemical Company, Creve Coeur, Mo., and E. E. Doherty of Bona Allen, Inc., Buford, Ga.

The prepared hide is first treated with a compound of the dialdehyde type, such as the chemical, glyoxal, which is used in making resins, and then with resin-forming agents such as urea or phenol (carbolic acid), or with combinations of these substances and formaldehyde. The rigidity which might result from the process is prevented by the addition of a checking agent.

Among improvements made are more satisfactory method of acidification of the resin-forming monomers, and the simpler control of flexibility of the leather even when cheap urea-aldehyde resins are employed.

The hides are tanned with glyoxal or other dialdehydes, or certain bifunctional compounds. One of the aldehyde groups attaches itself chemically to the protein in the hide, the other remaining free to react with certain resin-forming compounds under suitable conditions.

The proposed and most likely commercially-desirable resin treatment involves the use of urea-formaldehyde mixtures or prepolymers slightly deficient in formaldehyde. Employment of a ration of one-to-five of monoalkyl amine to urea yields leathers of greatly improved flexibility without loss of the highly desired "fullness" and "firmness" sought by the tanner.

A new process for dyeing and printing decorative fabrics woven of incombustible glass fiber makes them safe from fire hazard as draperies in public assembly rooms.

Decrease of Available Fuels Sparks Search for New Energy

Power Wanted

By A. C. MONAHAN

➤ THE FUTURE of the present machine age demands new sources of power. There is fuel enough for the needs of today, but all are agreed that the supply of the natural energy-producing fuels may some day be exhausted. This is particularly true for the liquids that power such mobile equipment as automobiles and airplanes.

Scientists are already busily engaged in a search for new fues and for fuel substitutes. Research is directed toward atomic energy, solar energy and the now-wasted power in tides and winds. There is coal enough to last for many centuries, although the better and more desirable grades may be exhausted much earlier. It is anybody's guess how long man will be able to get crude oil or natural gas from the crust of the earth. Wood will always be available if proper forestry practices are followed.

But it is certain that new sources of power will be needed for future years, and are needed even now so that present fuels can be made to last as long as possible, particularly for specific applications.

While it is true that the United States has a greater supply of coal than most nations of the world, this fuel can not be used directly to power the 40,000,000 motor vehicles on its highways or the many thousands of planes in the air. These require a mobile source of power, such as is available from liquid or gas-burning internal combustion engines.

These are dependent largely on liquid fuels, mostly petroleum products, athough alcohol and other chemicals might be used. It is important that practical methods be developed as rapidly as possible to make liquid fuels from coal, shale oil and tar sands to conserve the underground petroleum which made the automobile age and the air age possible.

Atomic energy has been widely talked about as power for aircraft in the future. Early applications need not be expected. But atomic energy as a source of power for aircraft promises achievements unobtainable with standard fuels, a scientist-engineer working on the problem recently stated.

From the results already obtained in reactor development, an atomic scientist recently said, "we should be able to design full-scale reactors, atomic-energy devices, to produce electric power in quantity. It is by no means clear at present how long this will take, but I believe that it should be within eight or ten years." The statement was by Dr. Robert F. Bacher of the U. S. Atomic Energy Commission.

"The real problem in developing nuclear reactors as a source of energy for the future depends, not upon the availability of raw material, but rather upon the two-stage process of first

making this production of energy technically feasible and then trying to make it economically feasible, he stated. Whether or not it will become economically feasible is the real question. I believe," he added, "that the long-range future for the development of atomic energy is very promising."

Although electricity is primarily for stationary plants, it is widely used in portable machines ranging from household eggbeaters to powerful drills used in mining. These applications, however, require wire connections to powerlines and are usable only within the length of the connecting wire. They are not for mobile units such as the automobile or the aircraft.

Most electrical energy produced in the world today comes from fuel combustion. The other great source is from water power. There is still plenty of undeveloped water power in the United States, and engineers predict large developments within the next generation or so. Some say that the amount available could easily be increased at least ten-fold. But, hydroelectric energy can never fill the total of America's power needs.

Many of the sites suitable for the development of water power with which to make electricity are entirely unsuitable for industrial activities. The terrain of the land may be responsible, but more often it is the distance from raw materials and markets. Electrical energy, of course, can be transmitted by wire relatively long distances, but the cost of transmission equipment is high, the loss of power is great, and there is a practical distance beyond which transmission is uneconomical.

Direct power from the sun, and power from the tides and the wind, are proposed as possible sources for energy used at the present time. Solar energy seems to hold the greatest present interest. It is widely used now, but it is not the daily energy reaching the earth in the rays of the sun. It is solar energy stored up decades and centuries ago in the wood that is burned, and the sunlight that grew the vegetation millions of years ago that provides the coal and petroleum of the present.

Waterpower might also be regarded as a source of indirect solar energy. Water in its travel circuit is converted to a vapor on the surface of the earth, lakes and seas largely by the energy of the sun. It drifts in clouds over the land, and the part that falls as precipitation on the highlands is the water available for power. What the scientists are now trying to do is harness the energy of the sun for direct and immediate use.

There is far more effort being devoted today to the direct utilization of solar energy than is generally appreciated. Present experimental work is largely for house heating, to save other fuels, and to gain experience for later application of sun heat to power plants. By the use of large double glass windows on the south side of a building, interiors are now being kept comfortably warm during sunshine and early evening hours. The problem is how to store up the heat of the sun for use at night and for cloudy winter days. For power applications this captured heat will have to be concentrated.

Scientists at the Massachusetts Institute of Technology are trying

several storage systems. In a dwelling completed early this year, water is used for heat storage. In a dwelling erected even earlier, and now in use, a chemical is used for the purpose. Glauber's salt is satisfactory for the purpose. This is a common substance, a form of sodium sulfate. Storage in iron, marble, concrete and other materials has also been tried.

The house with the sun-heated water is an ordinary one-story building with five rooms, except for its roof structure. The south slope of the roof, with the heat collector, inclines 57 degrees with the horizontal, presenting 400 square feet on which the rays of the sun are received. Their heat passes to a tank of water. When warmed by the sun, the water is pumped to a storage tank, and from there to room radiators as needed.

The principle behind the use of Glauber's salt, or certain other chemicals, makes use of latent heat, or what is now more commonly called heat-of-fusion. It is the heat necessary to convert a substance from a solid to a liquid state, and is not evident in a temperature rise. It takes as many calories of heat, for example, to change ice into water as it does to raise the temperature of the resulting water up to about 175 degrees Fahrenheit.

The system of heat storage in a chemical used in the M. I. T. experimental house is largely the work of Dr. Marie Telkes of the Institute staff. The chemical is sealed in containers. There is no loss of the material. Glauber's salt melts at about 90 degrees Fahrenheit. This is low enough to result in liquefying when the rays of the sun are focused on it, even in winter weather. When heat is needed in the house, air from the rooms is circulated about the sealed containers by use of a fan or blower.

The same research that has developed the best types of propellers for airplane propulsion has been applied to windmill blades to capture the greatest possible amount of the energy of the wind. Also blades have been developed to operate when the air movement is very low. Considerable success has been obtained. Windmills of the future may play an important part in generating electricity to supplement energy from waterpower and other sources. The supply delivered will be erratic, dependent upon the winds. Wider use of windmills in farm pumping and operating generators to feed storage batteries may be expected.

Tidal power has been used for many years in various parts of the world. It is regular and reliable, but there are relatively few sites where the tides are high enough to produce economical power. The high tides on New England's rocky coast can produce power to drive electric generators. To use them or not is largely a question of economics.

Oil in a Russian field not yet highly developed, is in a 2000-mile curved area stretching from the frozen tundras along the Arctic ocean southward through the Ural-Volga region to near the Caspian sea.

The buri palm nut of Brazil may become an important source of table oil; this palm is botanically Diplothemium candescens.

Not Yet Found, Second Proton Needed To Make Nature Symmetrical

Negative Proton Predicted

➤ WANTED: A missing atomic particle, the negative proton.

This missing particle look-out was broadcast by Drs. Julius Ashkin, Theodore Auerbach, and Robert E. Marshak, University of Rochester physicists.

Because there are both positive and negative electrons, although only positive protons are known so far, the scientists suggest nature, to be symmetrical, should also have a negative proton. Such a particle might be detected by exposing photographic plates to cosmic rays at very high altitudes reached by balloons.

"Electrons have been known for a long time to exist in two different varieties of the same mass but opposite charge," a report to the National Academy of Sciences said. "The more abundant electron has a negative charge and is found in atoms in the region close to but primarily outside the central nucleus. The less abundant positively charged electron is not a permanent constituent of the atoms as we know them but is produced in a variety of processes taking place in the nucleus or in the immediate surrounding region.

"When brought into close proximity the two may disappear or be annihilated in a single act, producing simultaneously two quanta of light. Thus a positive electron in the presence of matter containing negative electrons has only a transitory existence and eventually suffers annihilation.

"Protons so far found in nature are all of one variety. These particles, which form one of the fundamental constituents of nuclear matter, are of postive charge and of mass approximately 2,000 times the mass of an electron. They have in common with electrons the feature of possessing an intrinsic spin or angular momentum equal to one half a natural unit. This numerical identity in the spin has long since led to speculation on possible further analogies between electron and proton. It is of interest to find out if a negative proton exists.

"A negative proton would be a particle of negative charge, of mass equal to that of an ordinary positive proton and capable of undergoing an annihilation process with the more abundant positive proton. For this type of annihilation process one finds by theoretical estimation that the most likely end products are two new charged particles known as mesons.

"The charge on these resulting mesons make their detection possible by the now standard technique of examining nuclear events in very sensitive photographic emulsions. Since the positive proton which is one of the partners in the annihilation event forms a part of the nucleus of an atom in the emulsion there will also be other charged particles emitted as a result of the shock of the annihila-

tion. The mesons, however, will be moving with much greater speed than the emerging nuclear constituents and will leave noticeably different tracks, thinner than usual, in the photographic emulsion. One would therefore expect to find an explosive event in the emulsion which starts with the entry of a very fast charged particle, the negative proton, and results in the production of only two fast moving charged particles, which are mesons, accompanied by some number of slowly moving charges.

"Because of the necessity to conserve momentum in the annihilation event the three fast tracks would all lie in the same plane forming an inverted Y-shaped figure with the angle between the two mesons somewhat greater than 90 degrees on the average. If this characteristic phenomenon were found in photographic plates we would have evidence for the existence of the negative proton."

Little World Without Radioactivity

➤ A LITTLE WORLD where there will be no dangerous radioactivity, no atomic bomb by-products, is now being created. It will be peopled by highly pedigreed mice, rats, rabbits and guinea pigs. But humans exposed to dangerous radiation at work or in any future atomic bombings will benefit.

The radioactive-free oasis is being established at the Jackson Memorial Laboratory at Bar Harbor, Maine. Its unique reversal of present trends at medical research laboratories was announced by its director, Dr. Clarence C. Little.

Our object is to develop for research throughout the United States, Canada and Europe a source of experimental material which at any time can be guaranteed to be a normal control population for a group of animals being used elsewhere, Dr. Little stated.

Radioactivity can permanently change living cells, among them the reproductive cells from which all future generations are formed. In order to understand such changes, to foresee them, to prevent, direct or evaluate them it is absolutely essential to have control animals completely isolated from any source of radioactivity or atomic energy. Radioactive isotopes are now being used in more and more laboratories in a search for cancer cures and in a search for better means of fighting atomic energy damage.

Results of use of a radioactive chemical in cancer must be compared with the course of the cancer in animals untreated. But if the ancestors of these untreated animals had been exposed to radioactivity through living in the laboratory where the chemicals were being tested, they would not give an accurate control to compare with the treated animals.

Besides excluding all radioactive isotopes or animals treated with them, the Jackson Laboratory will have special isolation rooms and units where any chemicals with cancer-causing properties will be used.

The laboratory is rebuilding the laboratories and re-establishing the animal colonies destroyed by fire a year ago.

The Story of Uranium

by Burton L. Hawk

➤ Gather around, dear readers; we have a strange story to tell. For this is the story of uranium, that spectacular metal which has so quickly skyrocketed to fame and has even surpassed gold as the most hunted metal in the Universe.

Our story begins in the year 1789 —over 160 years ago. This was the year that struggling young America was electing its first president—George Washington. And this was the year that Martin Heinrich Klaproth, a German chemist, decided to investigate the properties of the mineral *pitchblende*.

Now in that time, the leading scientists agreed that pitchblende was an ore of zinc and iron. And Klaproth thought so too; that is, until he dissolved the ore in nitric acid and then added potash. A yellow precipitate formed which dissolved upon further addition of potash. Indeed, this was a strange reaction, not due to any known substance. So, Klaproth rightly assumed that he was now dealing with a new element, and he named it uranium after the newly discovered, planet, Uranus.

When one discovers a new element, the first thing to do is to obtain it in the elemental state. This Klaproth tried. He heated the yellow oxide of uranium with charcoal in a crucible, which was then the accepted method of reducing ores. He obtained a black powder which he concluded must be uranium.

For over fifty years the scientific world considered this black powder to be uranium. However in 1841, the young chemist Peligot proved that the black powder was not uranium, but an *oxide* of uranium.

Since it was apparent that uranous oxide could not easily be reduced, Peligot tried heating the anhydrous chloride of uranium with metallic potassium in a platinum crucible. The ensuing reaction was so violent that the crucible became white hot! After cooling, Peligot examined for the first time the black metallic powder which was uranium.

Another fifty years passed and uranium was practically forgotten. Then in 1896, Henri Becquerel placed a salt of uranium along with a photographic plate in a drawer. Later when he went to remove the plate he noticed that it was fogged as if it had been exposed to light. But this was impossible! The plate was protected with black paper and no light had reached it. Since the only substance near the plate was the uranium compound, Becquerel assumed correctly that some mysterious radiation emitted must affect the photographic plate. His later experiments proved that all uranium salts emit penetrating rays which will darken a photographic plate. Thus was born a new science: *radioactivity*.

Two years later, M. and Mme. Curie discovered the highly radioactive element, radium. The fame of radium spread fast and far, and once

more uranium was practically forgotten.

Those were golden years in the history of science! Strange and fascinating new elements were being discovered. Old and staid theories were exploded overnight. The imagination of man was stirred deeply as he reached further and deeper into nature's mysteries and secrets of creation.

Meanwhile, what of uranium? Well, it was the heaviest element, the "mother" of radium. . . . .otherwise not important. "Extremely difficult to isolate," the chemistry textbooks stated. . . . ."and for which no use has been found. . . . ." And the prospector continued his frantic search for gold, silver and platinum. Uranium? Never heard of it! Is it a metal? Any value?

But a few brilliant scientists were not by-passing uranium. Quietly and behind the scenes they were thinking . . .planning. . .experimenting.

Then in late 1941, the- Westinghouse Electric Company succeeded in producing a few ounces of pure uranium. By November 1942 this production was increased to a total of 6000 lbs. From Canada and the West came the ore—the brown oxide of uranium. This was treated with hydrofluoric acid to produce uranium tetrafluoride by the DuPont Company at Pennsgrove, N.J. and by the Harshaw Chemical Co. The tetrafluoride was then transported to Westinghouse where it was subjected to electrolysis to produce the pure metal. The extremely difficult isolation of uranium had been accomplished!

Why all this sudden interest in uranium? Well, you know the rest of the story. Atomic bomb, atomic energy, radioactive isotopes, plutonium and uranium have become familiar words to everyone. And thus we bring our history of uranium to date. The once useless metal is now invaluable, for it is the starting point in all types of atomic research.

Indeed, the future of the world seems now to depend upon which nation can secure the most uranium. The United States Government is so anxious to obtain uranium that it has offered $10,000 to the person who makes a rich "strike" of ore in the United States. Are you interested? Then send for the booklet, "Prospecting for Uranium," published by the U.S. Atomic Energy Commission. It can be obtained from the Superintendent of Documents, Washington, D.C. for 30 cents.

Not in their wildest dreams could Klaproth or Peligot have visualized the final utilization of the metal they discovered and isolated. And neither can we visualize the future of this spectacular metal. It can be used to produce horrible weapons of mass destruction and suffering. Or it can be used to cure and to create means to provide a better way of life. Let us hope and pray that it is used for the latter.

Now dear readers, we have told our story. Here we will stop. But our story is not ended. . . .and where it will end. . . .and how it will end. . . we cannot tell.

Over 1000 different chemicals are used in building an army tank and over 2000 in making a battleship.

Cermets Combine Qualities Of Ceramics and Metals

No Common Clay

Reprinted from the Industrial Bulletin of Arthur D. Little Inc.

➤ Ceramics and metals can now be combined to make a new material for turbine blades which promises to increase the temperature, and thus the efficiency, at which gas turbines for aircraft and other applications can operate. Ceramic materials have been widely used for linings and non-moving parts of gas turbines, but for use in moving parts they are too brittle and subject to cracking with quick temperature changes. The new "cermet" combinations (also called "ceramals" and "metamics") are usually made by pressing together the components in powdered form, and seem to possess better properties than either of the components, while minimizing many of the disadvantages. Research on these materials is still at a preliminary stage, but the early test data are encouraging. Several new metallic alloys have also been developed to withstand stress and corrosion at high temperatures, but they are more subject to creep and failure under the conditions encountered in gas turbines and jet engines.

In the gas turbine, the turbine rotor is driven by the exhaust blast from the burning fuel, and the blades are subject to extremely high temperatures, as well as to a corrosive atmosphere and the strain of whirling at thousands of revolutions per minute. Present metal alloys for turbine blades limit temperatures to about 1500°F., which gives the engine an efficiency of about 24 per cent. Designers welcome new materials which permit even small temperature increments, since a rise to 1800°F. would mean an engine efficiency of about 28 per cent. The new materials, if successful in other respects, would permit operating temperatures of at least 2000°F.

In the jet engine for aircraft, the same exhaust which propels the aircraft also drives a turbine which sucks air into the combustion chamber. Although a rise in operating temperature beyond 1500°F. would not improve the jet engine's ratio of fuel input to power output above about 14 per cent efficiency, there would be an increase in the absolute thrust obtained.

German ceramists experimented with mixtures of aluminum oxide and powdered iron; an extensive research program in this country has substantiated the meager results obtained by the Germans and has yielded much new information. Standard powder metallurgy techniques are usually used in the fabrication of cermets. The metal and ceramic grains are milled together to the desired size, and are frequently held by a temporary binder, such as wax. The pieces are then pressed in molds at a pressure of 10,000 to 100,000 pounds per square inch. The wax is burned out at a relatively low temperature, and the final firing is in the temperature range between 2500°F. and 3000°F.

This firing takes place in a carefully controlled atmosphere of argon, helium, nitrogen, hydrogen, or sometimes water vapor, or in a vacuum, which helps the particles of metal and ceramic to fuse to a solid structure. In the resulting combination the metal bonds together the grains of ceramic material. Apparently the resistance of the metal to thermal shock is transmitted to the brittle ceramic material, while the resistance to high temperatures which is characteristic of the ceramic is imparted to the metal.

Other Techniques

Other interesting techniques which have been tried are evaporating a mixture of the two powders onto a metal surface under vacuum, and flame spraying a molten combination onto a metal core, to lay down a thin coating of cermet. Impregnation of a piece of porous ceramic with molten metal has also been successful. Some cermets during tests for their ability to withstand rapid temperature change were heated and quenched through several cycles and they showed considerable improvement in strength over the original untreated samples, similar to the effect of heat treating of metals.

The possible metal-ceramic combinations are almost endless. The ceramics include borides, carbides, oxides, spinels, or combinations of these, while the metal could be almost any of the heat-resistant metals or alloys. Only a few combinations have been tested thus far.

To date only a few actual turbines using cermet blades have been tested, and the results have not been conclusive. New compositions are continually being tested for physical properties in various laboratories, and the more recent of these tests are especially promising for the extreme conditions which may be encountered in future aircraft turbines. When and if the technique is perfected, applications outside the gas-turbine field will probably be found. A possible one is in shearing knives for metallurgical operations, which require high abrasion resistance at elevated temperatures. Valve seats which can be ground smoothly and have good compressive strength are perhaps another place where the cermets may be important.

Chemical Shows Protein In Cells

➤ A NEW TOOL for prying into the secrets of cell life is found in phosphotungstic acid. It has been used by Drs. A. Engstrom and M. A. Jakus of the Karolinska Institute, Stockholm, to find out where in the cell the greatest concentrations of proteins occur.

Proteins, which are the food materials that become the actual replacement parts of living matter, have the property of binding phosphotungstic acid. The areas in which this occurs become less transparent to X-rays, so that cells treated with the acid and then irradiated will give light-and-dark patterns telling of the distribution of the proteins.

Jams and preserves can be successfully made from strawberries and raspberries that have been frozen and stored for months.

Steel's Own Silicon Used To Form Protective Coating

Glass Overcoat For Steel

A New Chemical Patent

Processes of Producing Glass Coated Silicon Steel U. S. Patent No. 2,492,682, Victor W. Carpenter, Franklin, and Samuel A. Bell, Middletown, Ohio, assignors to Armco Steel Corporation.

➤ IN THE COPENDING application of ourselves and Joseph E. Heck, Serial No. 389,962, filed April 23, 1941, and entitled "The production of silicon steel sheet stock having insulative surfaces," which has now matured into Patent No. 2,385,332 dated September 25, 1945, there is described a process of producing thinly and uniformly a glassy, insulative coating upon silicon steel stock. The process as practiced and as disclosed in that application involves a plurality of steps: The silicon steel is subjected to a heat treatment in a continuous furnace in an atmosphere of "wet hydrogen." This results not only in decarburization, which improves the electrical qualities of the steel, but also oxidizes silicon at or near the surfaces of the steel to silica while leaving iron unoxidized, a phenomenon which we have referred to as "preferential oxidation."

After this treatment the silicon steel is coated with a material capable at once of acting as a separator during annealing and of combining with silica to form a glass-like substance. Of such materials magnesia has been found the best and most available. It is mixed with water, whereupon it hydrates in large part to magnesium hydroxide, forming a slurry with which the silicon steel is easily coated. The coating is then dried.

Next the coated silicon steel is subjected to a high temperature box anneal, in which several actions occur The magnesium hydroxide gives up its combined water, reverting to magnesium oxide or magnesia. The silica formed near the surfaces of the silicon steel tends to migrate to the surfaces. Upon further rise in temperature, some of the magnesia combines with the silica to form a glassy coating next and firmly bound to the surfaces of the silicon steel, the remainder of the magnesia acting as an annealing separator.

The thickness of the glassy coating is rigidly controlled because it depends upon the silica produced in or on the sheet surfaces; and it is both thin and uniform. After annealing, the silicon steel sheets or strips are easily separated or decoiled; and the excess magnesia may readily be brushed or cleaned from their surfaces leaving the durable insulative film.

The objects of the present invention are the provision of improvements in the procedure for producing glass-coated silicon steel, accompanied by savings in cost and the attainment of improved products.

These and other objects of the invention which will be set forth hereinafter or will be apparent to one skilled in the art upon reading this

specification, we accomplish by the procedure which we shall now outline in an exemplary embodiment.

While excellent commercial results have been obtained in the process of the copending application, experience has indicated that there are a number of disadvantages in the conversion, in the box annealing step, of the magnesium hydroxide to magnesia. The evolution of large quantities of water in the annealing box renders atmospheric control difficult, and also necessitates the use of special heating cycles, since the combined water in the hydroxide begins to come off at approximately 660°F. When the dehydration of magnesium hydroxide occurs during box annealing there is usually a difference in appearance of the glassy film between the center and edges of the sheets, which we believe due to water from the center of the charge passing between the hotter edges. On occasion a phenomenon of peeling of the coating at the center of the sheets is encountered, which is not explained, but seems related to the matter of water elimination, since it does not occur in the procedure of this application.

These considerations indicate that it would be desirable to eliminate the water prior to the box anneal. It should be explained at this point that we are referring to the chemically combined water in the magnesium hydroxide. The free water in the initial slurry is quite easily and rapidly driven from the coating on the steel by heating to 212°F. or slightly higher, as may be done with gas flames playing upon the surface of the steel. Such temperatures are well below oxidation temperatures and do not affect the qualities of the steel.

But as explained above, the magnesium hydroxide requires heating to temperatures of 660° and higher before its combined water begins to come off. Thus, attempts at dehydration, as we use the term, require heat treatments of some considerable magnitude and cost; and the addition of a separate step and furnace is economically unsound. Moreover the temperatures are well above the oxidation temperatures for iron and, as we have found, the heat treatment would have to be conducted in a protective atmosphere, adding to the expense. Depending upon how the treatment is conducted, it might deleteriously affect the electrical properties of the steel.

Again a lengthy heat treatment was thought to be indicated, at relatively moderate temperatures, say not more than one or two hundred degrees above 660°F. Attempts have hitherto been made to dehydrate magnesium hydroxide to serve as a separator on ferrous sheets prior to box annealing. The understanding was that slow drying resulted in tight adherence, and drying times of four to five hours have been recommended. It was further understood that rapid evolution of water vapor would disrupt the coating and blow or blast it from the surfaces of stacked or coiled materials.

We have, however, found that these problems can be met and solved by the procedure herein outlined.

Having otherwise finished and cleaned our silicon steel sheet or strip (in the claims we use the word "stock" to include sheets or strip material) we first coat it with a slurry

of hydroxide coating substance. Preferably, as indicated, we use magnesium hydroxide, but other substances will serve, e.g. calcium hydroxide. Then the free water is driven from the coating by gentle heat, as by passing the stock through or against open gas flames.

The coating may be done in any suitable way as by dipping or spraying, and it is usual with us to pass the coated stock through rubber wiping rolls to control the thickness of the coating. Driving off the free water is desirable because roller conveyors or pinch roll combinations subsequently used to move the stock tend to pick up and accumulate wet coating, and will give trouble. When the free water is gone, we have found that the stock is easily handled through subsequent operations by pinch roll or conveyor means without disruption of the coating, with no greater precautions than the avoidance of scraping contact, and the driving of the rolls at peripheral speeds as nearly as possible the same as the linear speeds of the stock.

The sheets or strips are then delivered to a continuous annealing furnace. By this we mean an elongated furnace in which all surfaces of the sheets or strips are open or exposed to the atmosphere of the furnace, to which end the sheets or strips are sent through individually. In this furnace the stock is subjected to a rapid rise in temperature in a controlled atmosphere.

We have found that at temperatures around 1550°F. in a continuous furnace we can drive off the combined water in our coatings within the space of about two minutes, which is a time of treatment well within the range of operation of continuous furnaces at good operating speeds.

The coating is not disrupted by our treatment, nor blown off.

But we have further found that with a properly controlled atmosphere in the furnace the decarburization and preferential oxidation referred to above can proceed concurrently and can be concluded within the same space of time. We therefore introduce into our furnace a non-oxidizing, hydrogen bearing atmosphere which may be hydrogen itself or any neutral atmosphere rich in hydrogen, e. g. cracked ammonia.

In order to perform the decarburization and preferential oxidation the furnace atmosphere must be hydrogen bearing and "wet." The ranges of temperature and moisture content set forth in the said copending application for this procedure are 1350 to 1650°F. for the temperature and 2 to 35% of water vapor by volume for the moisture content of the furnace atmosphere. In the process of the present invention temperatures below about 1500°F. have been found to produce so slow a dehydration of the magnesium hydroxide that it becomes difficult to accomplish it within the scope and normal speed of conventional open annealing furnaces. On the other hand, if the temperature is carried much above 1650°F., while dehydration becomes more rapid, decarburization becomes slower; and since for most high quality silicon steel decarburization is important, we set forth as our preferred temperatures those lying between substantially 1500° and substantially 1650°F. Within these limits treatments of the order of about two minutes have been

found satisfactory for dehydration, decarburization and preferential oxidation, from one to four minutes being a general operating range.

We have also found that at such temperatures in the ordinary continuous furnace the amount of water given up by the coating on the sheet or strip stock is generally sufficient to maintain a desired working humidity of the furnace atmosphere. This constitutes an important advantage and economy since the maintenance of furnace humidity has always involved something of an operating problem. Needless to say, however, no departure from the principles of our invention is made by practicing additional controls upon the furnace atmosphere or by adding moisture to it in other ways.

It is of the utmost significance, however, that we have found that the decarburization and preferential oxidation proceed in our furnace concurrently with dehydration of the magnesium hydroxide coating and are not inhibited or prevented by it.

By way of a single example, we have found that silicon steel stock of .013 guage containing initially .025% of carbon when coated with magnesium hydroxide, dried as described for the elimination of free water, and then continuously annealed for two minutes at 1550°F., had its carbon content lowered to .0065% and the water content of its coating lowered from an initial 30.5% to 2.6%. Also sufficient silicon in the silicon steel was oxidized to silica to produce a satisfactory glassy coating in the subsequent steps.

At the conclusion of the steps just described the silicon steel stock is stacked if in sheet form, or coiled if in strip form, and is then box annealed. The box annealing is usually and preferably done in an atmosphere of dry hydrogen at a temperature of or around 2100°F.

Hitherto the box annealing of undehydrated magnesium hydroxide coated stock involved a very slow heating up to 1100°F., occupying about 24 to 30 hours for a 20 ton charge. During this initial heating cycle the chemically combined water was driven off from the magnesium hydroxide. Only thereafter could the material be raised to a temperature of 2100°F. which was the preferred annealing temperature. It took approximately 50 hours, following the above cycle to get the material up to the maximum temperature. It then was soaked for 24 hours at around 2100°F. and slowly cooled to a temperature below 1000° before the box was opened.

By treating our materials as set forth above, the initial part of the heating cycle which has just been outlined may be dispensed with, and the material may be raised to the highest temperature as rapidly as is consistent with good furnace operation in the particular equipment at hand. Thus a considerable saving may be made in fuel or power by reason of the shortened time cycle. Control of the atmosphere in the annealing box is also facilitated since it is not necessary to sweep from it large quantities of moisture driven off from the coating. During the anneal the ultimate electrical properties of the silicon steel are developed and the actions noted in the above entitled copending application occur, namely the migration

of silica to the surfaces of the silicon steel stock and its combination there with some of the magnesia to form the desired thin controlled uniform glassy coating tightly adherent to the stock surfaces. The remainder of the magnesia acts as a separator during the anneal and is easily removed from the glass coated stock thereafter.

Fiber of Protein is Cotton, Too

➤ FIBER FOR textiles has been successfully produced at the New Orleans Regional Research Laboratory of the U.S. Department of Agriculture from cottonseed protein. Its production makes the cotton plant a dual source of clothing and other textiles.

This new manufactured fiber is about three-fourths as strong as wool when dry, feels soft to the hand, and has good dyeing characteristics. Its natural color is yellow or light orange. Its wet strength is about 40% of the dry strength.

Another new synthetic fiber is also produced by the laboratory. It is made from a chemically modified cellulose from wood or cotton. Chemically it is sodium carboxymethyl cellulose and the salts of certain metals, including lead, copper and aluminum. It is colorless or lightly tinted, depending upon the metal used.

This unusual fiber will dissolve in soapy water or other alkali solutions. Its principal use will probably be for a "scaffold" fiber in the weaving of novel fabrics from various textiles. It has adequate strength for this purpose, a dry strength about equal to that of wool or slightly less than half that of cotton.

The metal-carboxymethyl-cellulose fibers should find uses similar to those of the alginate fibers, made from alginic acid from seaweed in England. This type is now used as supporting thread in weaving fine worsted yarns in making light-weight wool fabrics that could not otherwise be woven. Another application is in making fine handkerchiefs and decorative goods.

Prisim Reveals Longer Wavelengths

➤ A NEW INSTRUMENT for science and industry has given wavelength measurements in a previously unknown range of the invisible infra-red spectrum, the Optical Society of America was told recently.

Measurements of infra-red wavelengths up to 39 microns—a micron is .00003937 inch—were made at the National Bureau of Standards in Washington, Dr. Earle K. Plyler reported. A prism made of thallium bromide and thallium iodide was used for the study.

The thallium bromide iodide prism, called KRS-5, has extended the wavelengths in the infra-red region from approximately 25 microns for potassium bromide prisms and about 15 microns for sodium chloride (common salt) prisms.

The new prism gives scientists a new tool for studying materials in a range of the infra-red spectrum which they have not been able to explore before. KRS-5 is not now available commercially, but it may find important industrial applications in the future for analyzing materials.

Food Additions Need Pre-testing To Safeguard Public

Chemicals May Endanger Foods

➤ CHEMICALS added to food, either to enhance its qualities or to protect it from plant pests, are a potential source of danger to our health. This warning was given by Dr. W. B. White, chief of the Division of Food, U. S. Food and Drug Administration, Washington, to the American Public Health Association meeting.

We need laws to protect the safety of foods by pre-testing of chemicals added to them, just as the present laws cover the safety of new drugs before they are released on the market, Dr. White declared.

Many chemicals, he said, are pre-tested for wholesomeness but a few have only been guessed at. The result in one case was over 100 deaths and in another permanent leg paralysis in several hundred persons. The deaths were caused by the incautious adding of the poisonous chemical diethylene glycol to elixir of sulfanilimide by a young chemist who thought it would be an ideal solvent for the drug. The many paralysis patients were the victims of a poisonous chemical added to alcohol during prohibition days.

These kinds of accidents are forestalled now by the Food and Drug Act. But present food laws give inadequate protection. Agene, or nitrogren trichloride, was used for 25 years for treating flour, and discontinued only last year after it was discovered to give fits to dogs. There may be other potentially dangerous chemicals in our foods but there is no way of avoiding them under present laws.

Dr. White cautions that the "situation calls for genuine concern about the future, but not for alarm or hysteria about the present."

Two resolutions have been recently introduced before Congress to make a study of the situation.

Hearings have been set by the Federal Security Administrator for January, on tolerances of chemical sprays on fresh fruits and vegetables. This is intended to be a pooling of information on insecticidal poisons and their near relatives which are used to spray on crops to preserve them.

"Wishful guessing" has also marked the use of DDT in the past. At one time it was claimed that, because there were no apparent ill effects in the use of DDT to delouse combat troops during the war, it was harmless. Since then it has been proven that DDT has harmful effects in experiments with rats. Cows were shown to secrete DDT in their milk when sprayed with it to kill flies. This situation was corrected but less is known about other insecticides which may be a chronic threat to the nation's health.

A fish scale, similar in composition to bone, is made of several layers of minute fibers covered with a layer of lime.

Latex Cold Water Paint Is Easily Spread and Washable

Rubber Film is Newest in Paint

➤ A NEW water-base paint that spreads as easily as butter, washes as easily as rubber, and presents no fire hazard was described in a paper by L. L. Ryden, N. G. Britt and R. D. Visger of the Dow Chemical Company, Midland, Mich., at the meeting of the American Chemical Society.

Part latex and part water, the new paint is strong enough to cling to the wall while being washed and yet smooth enough to release dirt easily. It "combines ease of application, low odor, attractive appearance, and excellent washability," the paper said.

Like synthetic rubber latex, the Dow chemists stated, the latex used in paint bears a remarkable resemblance to ordinary milk. Its milky appearance is due to countless millions of tiny balls, too small to be seen in an ordinary microscope, that are dispersed in the water which composes about half of the latex composition. Each ball is soft and rubbery, so that when the latex is spread on a smooth surface and allowed to dry, these little balls come closer and closer together as the water evaporates. Finally they join together in a thin sheet of highly elastic, rubber-like film, resembling the texture of an ordinary rubber balloon.

This film of tiny rubber balls holds together the paint's thin layer of pigment, and also holds the pigments to the painted surface.

The fact that the water-base paint depends only on the drying of the water to produce the pigment binding film accounts for the paint's rapid drying time and the complete absence of turpentine, solvents, oils, and their accompanying strong odors, it was said. The absence of a thick, sticky oil base also explains the paint's ease of application.

Water-base paints have been in use for years, but in the past they could not be washed without coming off, according to the paper, or, if they could be washed, they could not be washed clean.

Here, then, is the significant difference, the report continued. Instead of drying oils or proteins, such as casein, of the ordinary water paints, the rubbery film of the latex paint provides a coating which is strong enough to stay on while being washed and smooth enough so that dirt is released easily, restoring the original beauty of the finish. This has been conclusively demonstrated both in the laboratory and in practical application.

This type of paint comes ready to apply and is more easily manufactured than many other types, according to the Dow chemists, and can be applied over fresh cement or plaster as soon as they are dry to the touch. The rubber-like binder in the latex is impervious to the alkali in cement or plaster which, even in small amounts, attacks the oils in ordinary paints, destroying the paint coating.

Antagonistic To Folic Acid, Drugs Give Temporary Improvement

Chemicals Aid Leukemia Patients

➤ CHEMICAL treatment of more than 200 persons suffering from cancer-like acute leukemia has brought about significant temporary improvement in from 11% to 50% of the cases.

Other forms of cancer have also been temporarily aided by the same chemicals, which are known to be antagonistic to the folic acid vitamin.

The chemicals used are aminopterin, amethopterin, and Amino-An-Fol.

Dr. Carl V. Moore of the Washington University School of Medicine, St. Louis, reported these encouraging results to the American College of Surgeons.

Dr. Moore has himself treated 17 patients with significant temporary improvement in six. Other doctors have treated 203 patients with the anti-folic acid chemicals, with remissions ranging from 11% to 50%.

One of Dr. Moore's patients, a four-year-old boy, has been practically well, or as the doctor put it, "in fairly complete remission," for a year.

Children apparently are helped more than grow-ups by these anti-folic acid chemicals, Dr. Moore said his and other doctors' work suggests. He emphasized, however, that the chemicals do not cure and that they cause severe toxic reactions. Painful inflammations and ulcers of the mouth, diarrhea and hemorrhage from stomach and intestines are among the toxic reactions caused by these chemicals.

Nitrogen mustard, the war gas chemical, often brings striking temporary improvement in Hodgkin's disease, and another chemical, urethane, has been helping patients with a bone marrow tumor, called multiple myeloma.

"It is obvious that the goal of destroying tumor cells without irreparably damaging normal tissue has not been attained," Dr. Moore declared.

"It is equally evident, however, that many of these substances are now of practical clinical value as palliative (relieving but not curing) agents in the management of patients with neoplastic (tumor) diseases, and that results are good enough to suggest that the ultimate goal of this type of chemotherapy may yet be achieved."

The "most important single practical development" in chemical treatment of cancer, he declared, probably is the use of female sex hormones in the treatment of cancer of the prostate gland.

Turkey is increasing its activities in the textile field; a wool yarn factory in Bursa is now making woolen fabrics, and cotton yarns and rayon staple yarn will soon be in production in Istanbul.

Rabbitskin is reported as now being used for the uppers of slippers and baby shoes in Germany.

Book Preview

Plant Growth Hormones

From a new book, The Chemistry and Physiology of Growth, published by Princeton University Press, $4.50.

THE FIELD of plant growth hormones, or auxins, has broadened out so enormously in recent years that I shall be able here to deal only with certain parts of it. The various applications to agriculture and horticulture, for instance, I will scarcely touch on, not because they are unimportant but because it seems preferable to center attention on the basic phenomenon of growth itself and how it is influenced by the hormones in plants.

One of the most striking features of the auxins is the multiplicity of their actions. Although they were discovered through their growth promoting effect on the *Avena coleoptile*, especially when applied to one side, and have been assayed in this manner ever since, it was soon made clear that they promote straight growth in many elongating stems and organs, i. e. enlargement along the longitudinal axis. Also, when such organs are slit and placed in a solution of auxin they undergo differential growth due to greater elongation of the outer than the inner tissues. The auxins cause formation of roots on stems, they cause cell division in the cambium and the formation of callus at cut surfaces; on the other hand they inhibit the growth of buds, and they also inhibit both the elongation of roots and the formation of the abscission layer on leafstalks and fruitstalks. Further, they trigger in some way the swelling of the ovary into a fruit, as pollination does, so that by applying auxin in the absence of pollination a normal but seedless fruit is formed. Finally, in pineapple but not (so far as known) in other plants, they even cause flowering.

This multiple action is in strong contrast with that of some of the animal hormones which typically cause specific effects on specifically reactive tissues. The multiple action has led to the view, expressed especially by Went (1938) and more recently by Gautheret (1944), that auxin acts as a mobilizing agent, bringing specific hormones to the tissue at which it is applied. According to this view, root formation when auxin is applied to the base of a cutting would be due to the mobilization there of a specific root-forming hormone. Experiments of Went, of Bouillenne, and of Cooper have given indirect support to this view, but the support is not strong and there is evidence against it. For instance, the rooting of small cubes of potato tubers when given high auxin concentrations, or the rooting of fragments of *Helianthus* hypocotyls in tissue culture containing auxin, are difficult to explain on this basis. The influence of leaves in promoting the rooting of cuttings after auxin treatment, brought out especially clearly by Rappaport, was at first thought to be due to the contribution of the specific hormone by the leaves, but in

the light of several more recent studies this effect is almost certainly nutritional. In at least one plant which is very heard to root with auxin treatment, the White Hibiscus studied by van Overbeek and co-workers (1946), the entire effect of the leaves could be replaced by nutrients, leaving no evidence for a hormonal factor.

Similarly the inhibition of lateral bud development by auxin applied at the tip was explained by the mobilization of bud growth factors at the point of auxin application, thus starving the buds of their essential factors. But inhibition has been shown to occur when auxin is applied to the lateral buds themselves; and although its mechanism is certainly not clear, it does seem to be essentially a direct effect of auxin on the lateral buds, rather than a diversion of other hormones away from these buds. It is, however, possible in this case that the action is due to the intermediate formation of an inhibiting substance by the auxin. Then again, the inhibition of root growth, a phenomenon exhibited by all auxins and in very low concentrations, is observed on isolated roots and is definitely exerted on the root itself.

All these considerations very strongly support the idea which was tentatively put forward more than ten years ago (Thimann, 1935) that auxin controls some fundamental *master reaction* in the cell. From this reaction, growth in size differentation, or even inhibition may follow according to the abilities of the cells concerned and their supply of water and other factors. It remains true that during the occurrence of the actual growth process there is some mobilization of materials, i. e. of water and nutrients. But this is a part of the growth process itself, rather than its primary cause.

Before dealing with this fundamental master reaction and the evidence for it, it will be worthwhile to discuss one of the fields which has been most active in the last few years, namely the relation between *free and bound auxin*.

In many standard test objects, growth is a simple function of the auxin applied, otherwise bio-assay would not be possible. From this it is but a short step to the concept that in the intact plant, or rather in a *part* of an intact plant, growth is a simple function of the auxin made available to that part. Of course nutrient materials have to be available too. This simple view had good success in explaining the facts so long as the auxin was determined by diffusion out into agar.

The introduction of a new method, i. e. extraction of the auxin from the plant tissue with an organic solvent, has gradually undermined all this. The very first such experiments, on *Avena*, showed auxin all through the plant, including the parts which are no longer growing. This destroys the simple correlation between auxin and growth and introduces a distinction between free auxin, which diffuses readily into agar, and bound auxin, which does not. As Went has shown (1942), it is only the former which is redistributed under the influence of gravity. Extension of the extraction method to other material has raised many problems. Let us consider first the case of green leafy tissue. In *Lemna*, for instance, auxin is set free

into ether continuously but very slowly. From dried material no liberation occurs, but on wetting it re-starts. The auxin is apparently being set free by hydrolysis. Proteolytic enzymes, especially chymotrypsin, liberate the auxin rapidly, so that we have here an auxin-protein. Using chymotrypsin we have attempted to locate this auxin-protein in the leaves of spinach, but there is more than one location. Some two-thirds of the auxin is associated with a globulin in the cytoplasm, but there is also much auxin in thoroughly washed intact chloroplasts. The other protein preparations do not contain large amounts. Alkaline hydrolysis does not liberate the chloroplast auxin, which explains our inability to extract auxin from *Lemna* by alkali. Avery and coworkers (1945) have reported the extraction of auxin from leaves of cabbage by boiling in alkali; but this cannot be a general phenomenon, for Miss Mes, with tomato leaves, finds as we do with spinach and *Lemna* that there is no liberation of auxin by alkali.

Very little auxin is liberated by simple short extraction of leaves with ether i. e. very little is free in the leaf. If this relatively large store of auxin in protein form were available to the plant for growth, it would be expected that leaves would continue growing much longer. One might expect giant cells and other evidences of high auxin concentration; but, further, one would expect to find the auxin very readily set free under natural conditions. Nevertheless many extensive experiments which we performed with different kinds of autolysis or action of autogeneous enzymes succeeded only in showing a very small liberation; no large fraction of the auxin was ever obtained even after many days' autolysis.

A measure of the free auxin in the tissue is given by the results of short-time extraction with ether, or in some cases, extraction of boiled tissue with either. Van Overbeek et al. (1945) have given evidence that the free auxin is essentially extracted in two hours. From our own data, based on twenty-four hours' extraction, the following figures may be given for the percentage of the total auxin given up in this way, i. e. the presumptive "free" auxin:

Fronds of *Lemna*	2 percent
The alga *Ulva*	2 percent
Avena roots	25 percent
Bean nodules	87 percent
Avena coleoptiles	almost 100 percent

The contrast between the two extremes is very striking, for the auxin in nodules and coleoptiles is very largely in the free state while that in the green tissue is overwhelmingly bound. It is difficult to resist the conclusion that this protein-bound auxin of leaves is *not* a reserve and is (mainly at least) unavailable to the plant for growth.

Seeds, however, show a very different picture. When dry seeds of *Avena* or of corn are dampened, auxin is very rapidly set free. Heating with alkali liberates auxin very rapidly in this material, as shown by Avery and coworkers (1941). It is now clear that this auxin, too, is protein-bound, and Gordon (1946) has prepared pure proteins from wheat which liberate auxin on hydrolysis with alkali or acid. We know that seeds deliver to the seedling a precursor which the

seedling tip converts to auxin. While this mobile precursor, partially purified by Berger and Avery (1944) does not itself seem to be a protein, it is clear that the auxin-protein of seeds is a true reserve or auxin-source, available to the plant for growth.

A word of warning is in place here. Tryptophane on heating with alkali forms a small amount of indoleacetic acid; casein and other proteins do the same. This phenomenon probably cannot account quantitatively for the auxin liberated by alkali from these seed proteins, but it certainly enters in. The fact that some seedlings are able to convert both tryptophane and tryptamine to free auxin should be remembered also. The demonstration by Haagen Smit, and later by Avery et al., and by Larsen and van Overbeek, that indoleacetic acid is no "heteroauxin" but a true plant auxin is of importance here.

Besides the above instances, there is still another type of behavior. When grass-stalks are laid horizontal, the nodes, which have long ceased growing, begin to grow on the lower side and this produces geotropic curvature of the stalks. Many years ago Schmitz showed by diffusion that this is due to the new production of auxin, in these nodes; here gravity, instead of merely redistribution of the auxin, as in the *coleoptile,* causes renewed production of auxin. Now van Overbeek *et al.* (1945) have shown in sugar cane that this new production is at the expense of bound auxin in the node; gravity in some way initiates the conversion of the bound to the free form. This phenomenon of gravitational release of auxin may be connected with another curious phenomenon. In pineapple (but not in other plants) application of auxin to the growing tip causes formation of flowers. Van Overbeek and his coworkers (unpublished) have now found that placing the pineapple plant horizontal has the same effect. This remarkable result may be due to liberation of bound auxin, but could of course be merely the result of geotropic accumulation of enough extra auxin on one side to start the flowering process.

In summary we may conclude that growth depends not only on the free auxin present but also on the ability of the tissue to convert bound auxin into the free form. The bound auxin is itself of many types: (1) that of the seed and perhaps the ovary which is made available for growth (2) that of the leaf which is not, and (3) that of the main axis, which may occupy an intermediate position, while (4) that in the coleoptile appears much more loosely bound than the types discussed above.

Salt Not Always Salty To Taste

➤ SALT does not always taste salty, according to Dr. Hubert W. Frings, associate professor of entomology at Pennsylvania State College. It may taste bitter or sweet.

You can tell more about how an inorganic substance is going to taste from the mobility of its ions than you can from its composition as a salt, Dr. Frings said. Epsom salts has high mobility of ions and its taste is not salt, but bitter. Lead acetate, also a salt, is sweet because of the low mobility of its ions.

How Motion and Radiation Are Related to the Atom

Motion Within the Atom

by HELEN M. DAVIS

➤ OF ALL THE *enigmas of modern science, none is more provocative than the attempt to read in the spectra of the elements the information about their atomic structure which is being broadcast directly from the heart of the atom itself.*

The following article is the fifth in a series in which the editors of CHEMISTRY *try to set forth in very simple language the background of this problem. In each one, the introduction is followed by a quotation from the writings of the scientists who have taken the great steps in solving the puzzle of the atom.*

Bunsen and Kirchhoff, in the first of the series, told how they made the first spectroscope. This was followed by Ångström's measurements of spectral lines, Rutherford's exploration of the atom's electric forces, and de Broglie's reconciliation of the wave and corpuscular theories of light through acceptance of the idea of light quanta.

Bohr's theory of atom structure in relation to spectral lines is quoted in this issue. Announced before the new mathematics of wave motion had become generaly known, this theory has suffered from oversimplification. Bohr's "jumping electron" does not swish through his planetary system like an errant comet. But first — let us review what we know about motion.

➤ WHEN WE SEE something moving we look for the cause that put it in motion. We can follow Newton's reasoning when he stated that, neglecting friction, a body once set in motion tends to continue its uniform motion in a straight line. Practically, we are so accustomed to seeing such motions modified by friction and by gravity that we expect to apply force to keep objects in motion. We have to make a special effort to consider motions like those of the planets which swing along without such renewal.

Within the "frame of reference" in which we live, motion illustrated by a baseball is much more familiar to us. The energy of living muscle starts the ball, with the force of the pitcher's throw. The ball may be slowed down by a variable amount of wind resistance. Its direction will certainly be changed gradually by the constant pull of gravity. When it hits the ground the immediate collision with the earth will stop it. If it collides instead with a well-aimed bat, such collision will change its direction of motion. If the ball bounces back to the catcher, we may thing of this change as *reflection* of the ball. The recoil of the catcher's hand and the hot place on his glove where the ball hit are other phenomena of motion, energy and resistance.

All these happenings are expected. Motion without them is unfamiliar. Thus it took a long time for physicists to work out the connection between

heat and the phenomena of molecular motion. They could not readily accept the idea of molecules in motion without a pitcher to start them from rest and an outside force to change their direction.

Kinds of Energy

Gradually a series of scientists worked out the puzzle, piece by piece. Heat is a form of energy. Energy is what makes things move. Other forms of energy are electricity and muscle power. There is more than a suspicion that electrical forces are at the bottom of all kinds of energy.

Things can be given energy by setting them in motion. Their energy is potential until "something happens," and kinetic when they hit something else and set it in motion.

The smallest particles of all substances are constantly in motion, and one way to increase their motion is to heat them up. When they are heated hot enough, many substances begin to glow and give off red light. The heat and light given off are both forms of radiation. As the radiating body becomes hotter, more colors are added to the light, making it yellower. The higher the temperature the closer the light comes to what we call "white," which is the combination of all the visible colors in sunlight.

Heat and light are, therefore, the same kind of energy. They come from motion of very minute forms of matter. In the time of Isaac Newton, about 250 years ago, there was a great deal of controversy over the nature of radiation. Newton felt that he could best picture the phenomena of light that he studied by thinking of a stream of tiny particles, which he named corpuscles.

Huygens countered with the wave theory. According to this picture, light is a sensation due to wave motion in the "ether," an imaginary substance invented to fill space as air fills a room or water the ocean. The wave theory won the argument, because it seemed to offer the simplest explanation for the puzzles then under investigation. Doubtless the dissimilarity between light and a thrown ball counted against the corpuscular theory, although both assumed that motion is a property of matter in its most finely divided state.

What is Matter?

During the following century the question of what matter, in its most finely divided state, is like received more and more attention. When it became necessary, in order to account for chemical compounds, to postulate the atom as a small particle incapable of further division, science took a definite stand on the side of discontinuous matter. When elements were found to give off spectra consisting of isolated lines at different frequencies, evidence began to accumulate pointing toward discontinuous energy units as well.

As soon as the electric current that would pass through a solution was found to be proportional to the valencies of the elements in solution, a clue was obtained as to the nature of chemical energy. The chemical entities in the solution, that move to one or the other pole carrying units of electricity, were named *ions* and the electrical units they transport were called *electrons*.

Molecules of salts, on going into solution in water, are found to break the valence bonds holding their atoms

together. The broken chemical forces then appear as positive or negative electrical charges on the parts of the molecules — the ions in the solution. Although ions preserve the individual characteristics of the elements, electrons are all alike and completely interchangeable. Each represents a unit quantity of electricity.

Multivalent ions are commonly formed by certain elements, and many elements may be forced by electrical excitation to lose more electrons than their normal number when in solution. Since these electron losses show up as differences in the numbers and patterns of their spectrum lines, there is a great deal of evidence that atoms are built up of numbers of electrons.

Since electrons are all alike and their charges repel each other, a nucleus of opposite charge, which would hold these collections of electrons together, was needed to complete the theory of the atom. It must be heavy, too, to account for the elements' atomic weights. Electrons weigh almost nothing, even on so small a scale.

Beginning as just an hypothesis, the idea that the nucleus of the hydrogen atom, now called the proton, is the fundamental positively charged particle has gained ground steadily in recent years. According to present theory, all the chemical elements are built up from these standard positive and negative units, plus the recently detected neutron.

Neutrons and protons make up the nucleus of every atom, while electrons circle around at a distance, each in its own orbit, in an arrangement often spoken of as something like that of the planets in our solar system.

But the solar system analogy is a vast over-simplification of the atom. Planets of our solar system do not seem, to us who inhabit one of them, to be merely disembodied electric charges. They are not all alike. There is no reason why more than one should not occupy the same orbit (the moon and the earth do). And there is no jumping from orbit to orbit in the one astronomical planetary system we know.

A system of electrons revolving in concentric ellipses around the nucleus is an understandable picture which fits many accepted facts about atom structure, except the fundamental one accounting for the lines in the spectrum.

During the first quarter of the present-century there developed a new branch of mathematics known as wave-mechanics. Under the stimulus of the new viewpoint that radiation occurs in quanta and that energy, as well as matter, is discontinuous, the new science of nucleonics unfolded.

It was during this period that Bohr formulated his theory of atom structure, in which each spectrum line represents the difference between two stable levels in electron orbits. Translating this mathematical concept into a mental picture, the line has been said to be caused by the "jump" of an electron from one orbit to another.

It will be seen from Bohr's paper here quoted that his "stationary" state means a state of undisturbed motion, such as might give rise to a set of standing waves. According to Bohr's calculations, radiation is emitted by "excited" atoms during transition from one such stable wave system to another.

The Chemist's Atom

THE THEORY OF SPECTRA AND ATOMIC CONSTITUTION. *Three Essays by Niels Bohr. Cambridge University Press, Cambridge, [England], 1922.*

➤ THE CONCEPTION of atomic structure which will form the basis of all the following remarks is the so-called nuclear atom according to which an atom is assumed to consist of a nucleus surrounded by a number of electrons whose distances from one another and from the nucleus are very large compared to the dimensions of the particles themselves. The nucleus possesses almost the entire mass of the atom and has a positive charge of such magnitude that the number of electrons in a neutral atom is equal to the number of the element in the periodic system, the so-called *atomic number*. This idea of the atom, which is due principally to Rutherford's fundamental researches on radio-active substances, exhibits extremely simple features, but just this simplicity appears at first sight to present difficulties in explaining the properties of the elements. When we treat this question on the basis of the ordinary mechanical and electrodynamical theories it is impossible to find a starting point for an explanation of the marked properties exhibited by the various elements, indeed not even of their permanency. On the one hand the particles of the atom apparently could not be at rest in a state of stable equilibrium, and on the other we should have to expect that every motion which might be present would give rise to the emission of electro-magnetic radiation which would not cease until all the energy of the system had been emitted and all the electrons had fallen into the nucleus. A method of escaping from these difficulties has now been found in the application of ideas belonging to the quantum theory, the basis of which was laid by Planck in his celebrated work on the law of temperature radiation. This represented a radical departure from previous conceptions since it was the first instance in which the assumption of a discontinuity was employed in the formulation of the general laws of nature.

The Quantum Theory

The quantum theory in the form in which it has been applied to the problems of atomic structure rests upon two postulates which have a direct bearing on the difficulties mentioned above. According to the first postulate there are certain states in which the atom can exist without emitting radiation, although the particles are supposed to have an accelerated motion relative to one another. These *stationary* states are, in addition, suposed to possess a peculiar kind of stability, so that it is impossible either to add energy to or remove energy from the atom except by a process involving a transition of the atom into another of these states. According to the second postulate each emission of radiation from the atom resulting from such a transition always consists of a train of purely harmonic waves. The frequency of these waves does not depend directly upon the motion of the atom, but is determined by a *frequency relation*,

according to which the frequency multiplied by the universal constant introduced by Planck is equal to the total energy emitted during the process. For a transition between two stationary states for which the values of the energy of the atom before and after the emission of radiation are E' and E" respectively, we have therefore

$$h\nu = E' - E'' \tag{1}$$

where h is Planck's constant and ν is the frequency of the emitted radiation. Time does not permit me to give a systematic survey of the quantum theory, the recent development of which has gone hand in hand with its aplications to atomic structure. I shall therefore immediately proceed to the consideration of those applications of the theory which are of direct importance in connection with our subject.

Hydrogen Atom

We shall commence by considering the simplest atom conceivable, namely, an atom consisting of a nucleus and one electron. If the charge on the nucleus corresponds to that of a single electron and the system consequently is neutral we have a hydrogen atom. Those developments of the quantum theory which have made possible its application to atomic structure started with the interpretation of the well-known simple spectrum emitted by hydrogen. This spectrum consists of a series of lines, the frequencies of which are given by the extremely simple Balmer formula

$$\nu = K \left[\frac{1}{(n'')^2} - \frac{1}{(n')^2} \right] \tag{2}$$

where n'' and n' are integers. According to the quantum theory we shall now assume that the atom possesses a series of stationary states characterized by a series of integers, and it can be seen how the frequencies given by formula (2) may be derived from the frequency relation if it is assumed that a hydrogen line is connected with a radiation emitted during a transition between two of these states corresponding to the numbers n' and n'', and if the energy in the nth state apart from an arbitrary additive constant is supposed to be given by the formula

$$En = -\frac{Kh}{n^2} \tag{3}$$

The negative sign is used because the energy of the atom is measured most simply by the work required to remove the electron to infinite distance from the nucleus, and we shall assume that the numerical value of the expression on the right-hand side of formula (3) is just equal to this work.

As regards the closer description of the stationary states we find that the electron will very nearly describe an ellipse with the nucleus in the focus. The major axis of this ellipse is connected with the energy of the atom in a simple way, and corresponding to the energy values of the stationary states given by formula (3) there are a series of values for the major axis $2a$ of the orbit of the electron given by the formula

$$2an = \frac{n^2 e^2}{hK} \tag{4}$$

where e is the numerical value of the charge of the electron and the nucleus.

On the whole we may say that the

spectrum of hydrogen shows us the *formation of the hydrogen atom*, since the stationary states may be regarded as different stages of a process by which the electron under the emission of radiation is bound in orbits of smaller and smaller dimensions corresponding to states with decreasing values of n. It will be seen that this view has certain characteristic features in common with the binding process of an electron to the nucleus if this were to take place according to the ordinary electrodynamics, but that our view differs from it in just such a way that it is possible to account for the observed properties of hydrogen. In particular it is seen that the final result of the binding process leads to a quite definite stationary state of the atom, namely that state for which $n = 1$. This state which corresponds to the minimum energy of the atom will be called the *normal state* of the atom. It may be stated here that the values of the energy of the atom and the major axis of the orbit of the electron which are found if we put $n = 1$ in formulae (3) and (4) are of the same order of magnitude as the values of the firmness of binding of electrons and of the dimensions of the atoms which have been obtained from experiments on the electrical and mechanical properties of gases. A more accurate check on formulate (3) and (4) can however not be obtained from such a comparison, because in such experiments hydrogen is not present in the form of simple atoms but as molecules.

The formal basis of the quantum theory consists not only of the frequency relation, but also of conditions which permit the determination of the stationary states of atomic systems. The latter conditions, like that assumed for the frequency, may be regarded as natural generalizations of that assumption regarding the interaction between simple electrodynamic systems and a surrounding field of electromagnetic radiation which forms the basis of Planck's theory of temperature radiation. I shall not here go further into the nature of these conditions but only mention that by their means the stationary states are characterized by a number of integers, the so-called *quantum numbers*. For a purely periodic motion like that assumed in the case of the hydrogen atom only a single quantum number is necessary for the determination of the stationary states. This number determines the energy of the atom and also the major axis of the orbit of the electron, but not its excentricity. The energy in the various stationary states, if the small influence of the motion of the nucleus is neglected, is given by the following formula:

$$-En = -\frac{2\pi^2 N^2 e^4 m}{n^2 h^2} \tag{5}$$

where e and m are respectively the charge and the mass of the electron, and where for the sake of subsequent applications the charge on the nucleus has been designated by Ne.

For the atom of hydrogen $N = 1$, and a comparison with equation (3) leads to the following theoretical expression for K in formula (2), namely

$$K = \frac{2\pi^2 e^4 m}{h^3} \tag{6}$$

This agrees with the empirical value

of the constant for the spectrum of hydrogen within the limit of accuracy with which the various quantities can be determined.

Spectra

If in the above formula we put $N = 2$ which corresponds to an atom consisting of an electron revolving around a nucleus with a double charge, we get values for the energies in the stationary states, which are four times larger than the energies in the corresponding states of the hydrogen atom, and we obtain the following formula for the spectrum which would be emitted by such an atom:

$$\nu = 4K\left(\frac{1}{(n'')^2} - \frac{1}{(n')^2}\right) \qquad (7)$$

This formula represents certain lines which have been known for some time and which had been attributed to hydrogen on account of the great similarity between formulae (2) and (7) since it had never been anticipated that two different substances could exhibit properties so closely resembling each other. According to the theory we may, however, expect that the emission of the spectrum given by (7) corresponds to the *first stage of formation of the helium atom*, i.e., to the binding of a first electron by the doubly charged nucleus of this atom. This interpretation has been found to agree with more recent information. For instance, it has been possible to obtain this spectrum from pure helium. I have dwelt on this point in order to show how this intimate connection between the properties of two elements, which at first sight might appear quite surprising, is to be regarded as an immediate expression of the characteristic simple structure of the nuclear atom. A short time after the elucidation of this question, new evidence of extraordinary interest was obtained of such a similarity between the properties of the elements. I refer to Moseley's fundamental researches on the X-ray spectra of the elements. Moseley found that these spectra varied in an extremely simple manner from one element to the next in the periodic system. It is well known that the lines of the X-ray spectra may be divided into groups corresponding to the different characteristic absorption regions for X-rays discovered by Barkla. As regards the K group which contains the most penetrating X-rays, Moseley found that the strongest line for all elements investigated could be represented by a formula which with a small simplification can be written

$$\nu = N^2K\left(\frac{1}{1^2} - \frac{1}{2^2}\right) \qquad (8)$$

K is the same constant as in the hydrogen spectrum, and N the atomic number. The great significance of this discovery lies in the fact that it would seem firmly to establish the view that this atomic number is equal to the number of electrons in the atom. This assumption had already been used as a basis for work on atomic structure and was first stated by van den Broek. While the significance of this aspect of Moseley's discovery was at once clear to all, it has on the other hand been more difficult to understand the very great similarity between the spectrum of hydrogen and the X-ray spectra. This similarity is shown, not only by the lines of the K group, but also

by groups of less penetrating X-rays. Thus Moseley found for all the elements he investigated that the frequencies of the strongest line in the *L* group may be represented by a formula which with a simplification similar to that employed in formula (8) can be written

$$\nu = N^2K\left(\frac{1}{2^2} - \frac{1}{3^2}\right) \quad (9)$$

Here again we obtain an expression for the frequency which corresponds to a line in the spectrum which would be emitted by the *binding of an electron to a nucleus, whose charge is Ne.*

Polonium For Static Electricity Dangerous

➤ DEVICES made of polonium, a highly radioactive metal, for eliminating static electricity may develop radiation hazards.

Dr. Fred Bryan and Louis Silverman of the U.C.L.A. Medical School atomic research group, found that serious radiation hazards may develop in the area around the devices.

Polonium is used in eliminating static electricity produced by belts and pulleys, paper passing over metal rolls and film over metal and plastic rolls. This radioactive metal emits alpha particles to form a conductive layer of ionized air between the dielectric material and a portion of the machine which is grounded.

A survey of certain industrial plants in the Los Angeles area revealed dangerous radioactivity in shelves and closets in which static eliminator devices were stored. Hands of an employee who handled the equipment were found to be highly contaminated even after repeated washing with soap and water.

The radiation of polonium does not penetrate the skin, but an internal hazard may develop from radioactive particles absorbed by inhalation or hand-to-mouth contact.

Such static eliminators should be used only when suitable monitoring instruments are available and personnel properly trained to handle radioactive material.

Uranium is One Big Complicated Family

➤ THE ATOMIC bomb element uranium is a family with probably seven members. And like a large human family, it can get pretty complicated.

Uranium 235 is the atomic bomb variety or isotope. It is found in natural uranium in small amounts.

Uranium 238 is the common metal which makes up most of the natural uranium found on the earth.

Other members of the family are: U-233, possible bomb stuff made from another element, thorium; U-234, made in the laboratory and not reported capable of releasing atomic energy; U-237 and U-239, also man-made and not believed to be fissionable. Seventh member of the family may be U-236. This isotope has not been reported, but chemists suspect it can exist for a very short time.

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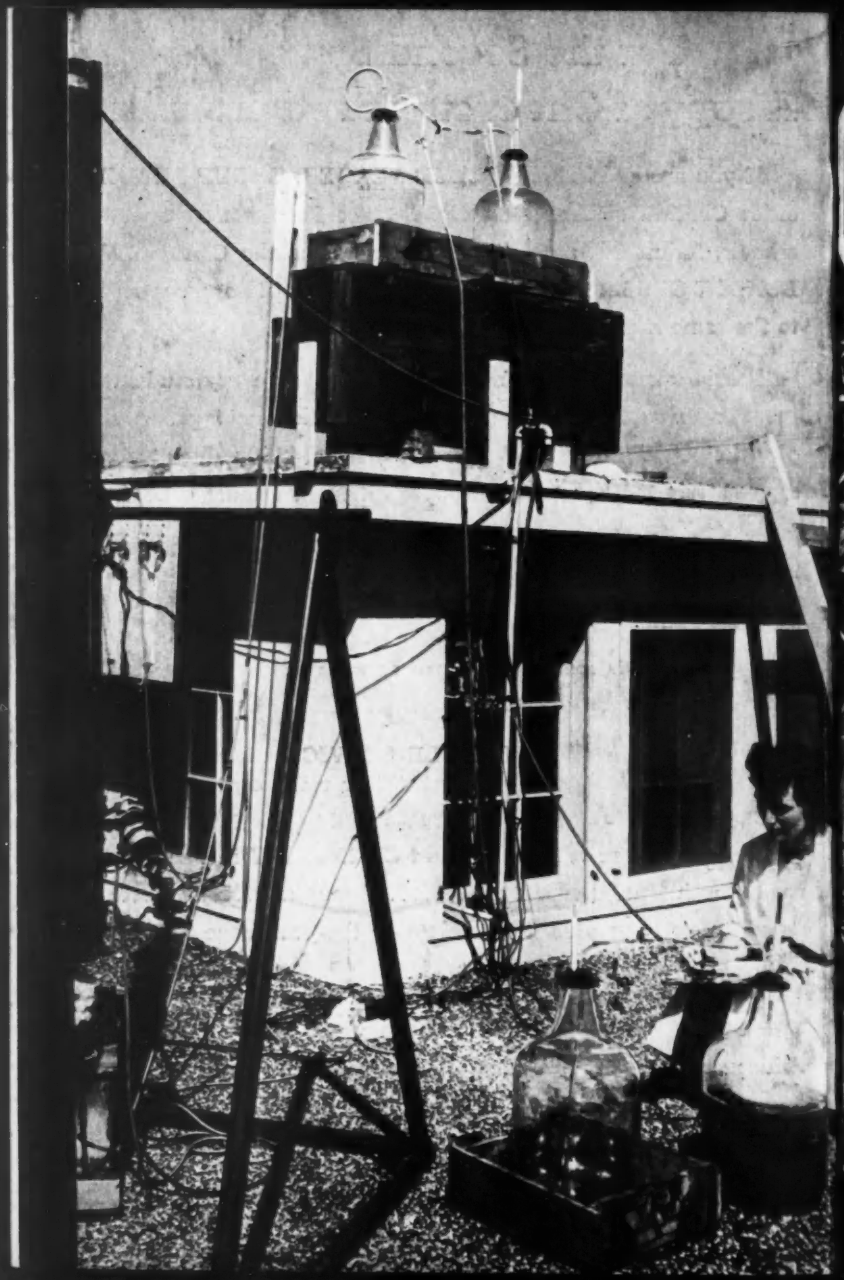
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